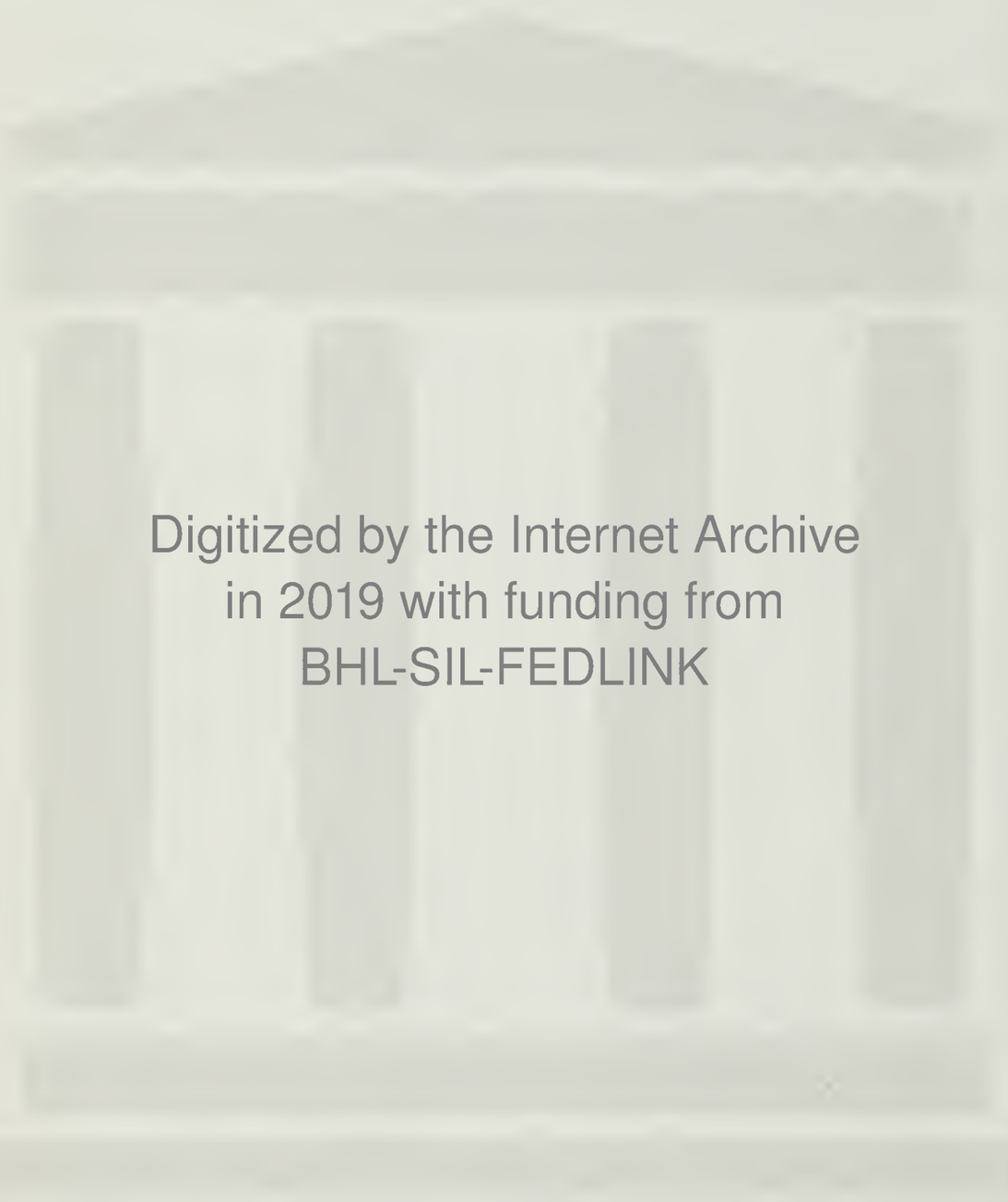
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A COLLECTION OF BRYOPHYTES FROM SUMMER ISLAND, DELTA COUNTY, MICHIGAN[1]

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Michigan State University, East Lansing[2]

Through the courtesy of Mr. Dan Stevens, we were able to spend several days during July, 1968, collecting bryophytes on Summer Island located in the channel between the Garden Peninsula, Michigan, and the Door Peninsula, Wisconsin (see Fig. 1). These peninsulas and the islands between them divide the waters of Big Bay de Noc and Green Bay on the west from Lake Michigan proper on the east. The Garden Peninsula extends about 25 miles southwestward into the lake, and Summer Island lies 2 miles off its tip.

At its maximum dimensions Summer Island is about 3 miles long and 1.5 miles wide (see U. S. Geological Survey 15 minute quadrangle for Fairport, Michigan). It rises 121 feet above the level of Lake Michigan to a maximum elevation of 701 feet A. T. near its center. The Middle Silurian Engadine dolomite, which forms a broad pavement and low ledges along the southern and southeastern shores, underlies the southeastern two-thirds of the island (Ehlers & Kesling, 1957). Dolomites and dolomitic limestones of the somewhat older Middle Silurian Manistique Group comprise the bedrock of the rest of the island. These Silurian deposits are a part of a broad band of carbonate rocks that extends from eastern Wisconsin, across the region just north of the Straits of Mackinac, through Drummond and parts of Manitoulin Islands, to the Bruce Peninsula, Ontario, and on into southern Ontario and New York State. The Niagara escarpment is a prominent physiographic feature across much of this region.

At the present time the island is uninhabited except during part of the summer when Summer Science, Inc., operates a camp for boys, of which Mr. Stevens is director. Most of the island is state-owned and is administered as a part of the Manistique River State Forest. Early lake fishermen established a village at Summer Harbor along the northeastern shore, but after a short period of occupation, this was abandoned in the mid-1800's. Although the forest covering the island has been partialiy cut over, relatively little other modification has been caused by man.

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[1]Contribution from the University of Michigan Biological Station. Research in part supported by National Science Foundation grant GB-6095 to Dr. H. A. Crum for Workshops in Bryology at the Station. We thank Dr. Crum for his help with the determination of several difficult mosses and Dr. J. Váňa, Charles University, Prague, Czechoslovakia, for information on *Jungermannia subulata.*

[2]Present addresses: Department of Botany, University of North Carolina, Chapel Hill, North Carolina (N.G.M.); and Department of Botany, University of British Columbia, Vancouver (R.L.H.).

Dry or moist *Thuja occidentalis* stands, often containing *Abies balsamea,* fringe the island. Inland these give way to deciduous forest dominated by *Acer saccharum* and *Fagus grandifolia,* but with some *Tsuga canadensis* and other tree species. A small portion of this forest apparently has never been logged. The east shore is marked by numerous springs which seep lakeward over dolomite pavement or beach sediments. The springs are often headed by wet *Thuja* thickets and shallow pools surrounded by the extremely rich assemblage of rare northern calciphile mosses for which the northern Michigan region is well-known. Large weathered dolomite blocks are common at places along the eastern and southwestern shores. Except for rotting logs and tree bark, all habitats encountered on the island are strongly calcareous.

Until our visit, apparently no one had collected bryophytes on the island. Delta County itself is poorly known bryologically, since only 14 species from the county are listed by Darlington (1964). Most of these were collected by either Steere (1934), who explored the Burnt Bluff escarpment between Fayette and Garden, or by C. F. Wheeler, an active early Michigan botanist whose travels took him throughout the state.

We report here 130 species of bryophytes, including 35 hepatics and 95 mosses, all of which were found during our stay on the island. Our collection includes all but 5 of the species listed for Delta County by Darlington (1964), namely *Blindia acuta, Fontinalis antipyretica, Polytrichum juniperinum* var. *gracilius, Sphagnum palustre,* and *S. squarrosum.* This compares with 87 species of liverworts (Miller, 1968) and 255 species (plus some varieties) of

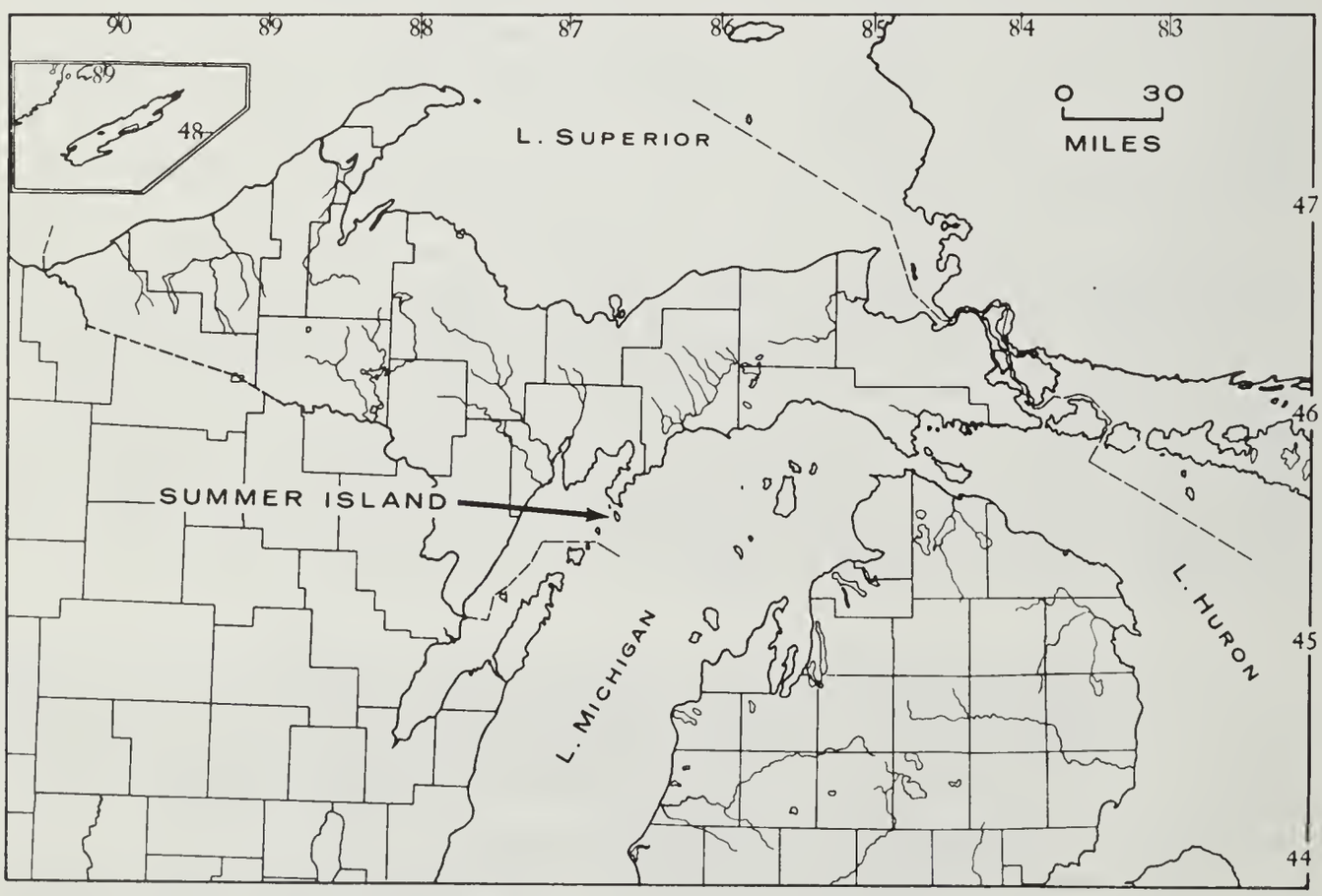

Fig. 1. Map of northern Michigan showing location of Summer Island.

mosses (H. Crum, in litt.) that are known to occur in the intensely collected region near the University of Michigan Biological Station, which includes Cheboygan, Emmet, Mackinac, and Presque Isle counties. The specimens cited in this paper have been deposited either in the herbarium of the University of Michigan Biological Station (all numbers preceded by H representing Halbert collections) or the herbarium of the University of Michigan (M numbers representing Miller collections).

Among the material we collected are two species that evidently have not been reported before from Michigan:

1. *Eucladium verticillatum* (Brid.) B.S.G.–This moss, a decided calciphile, occurs otherwise in eastern North America from Ontario to Florida and west to Texas and Oklahoma; also scattered in western North America from British Columbia to Baja California, eastward to Colorado, New Mexico, and Sonora; known also from Japan and Europe (throughout). Sometimes becoming encrusted with calcium carbonate and forming lime-tufa.

2. *Lophozia collaris* (Nees) Schust. [*Leiocolea muelleri* (Nees) Joerg.] – The range of this liverwort in North America is imperfectly known because of confusion with the more common and similar *L. badensis* (Gottsche) Schiffn. *Lophozia collaris* differs from this species in having underleaves and smaller leaf cells with distinct trigones (see Schuster, 1969, pp. 392-398). Our Summer Island material consists of a mixture of male and female plants bearing terminal antheridial "spikes" and perianths, respectively. Underleaves are present on sterile shoots but are difficult to demonstrate because they are mostly small and hidden by rhizoids. Marginal cells of the leaf lobes average 22 μ in diameter and the leaf cuticle is clearly verruculose. Sparsely dentate bracts subtending the perianth were noted also. All of these characters agree with Schuster's interpretation of *L. collaris* and we do not hesitate to place our specimen here. In North America known mainly from eastern arctic and subarctic Canada, but likely of wider distribution; the only previously known stations in the Great Lakes region appear to be two in Minnesota (*ibid.*).

SPECIES LIST BY COLLECTING LOCALITY

Shaded dolomite ledges and boulders, dry or moist, NE shore of island just W of Summer Science Camp, NW¼ Sect. 27 (T. 37 N., R. 19 W.), 16 July 1968.

Abietinella abietina (Hedw.) Fleisch.–Shaded ledge, *H907*; soil, base of *Populus tremuloides, H926*; humus over dolomite, *H984*; horizontal face of boulder, *M4646*.

Anomodon attenuatus (Hedw.) Hüb.–Exposed dolomite, *H960*.

A. rostratus (Hedw.) Schimp.–Shaded and exposed dolomite, H915; humus over rock, *H919;* humus on ledge, *H945;* side of boulder, *M4648*.

A. viticulosus (Hedw.) Hook. & Tayl.–Shaded and exposed dolomite, *H909;* shaded ledge, *H930;* shaded boulder face, *M4649*.

Barbilophozia barbata (Schmid.) Loeske–Crest of ledge, *M4644*.

Blepharostoma trichophyllum (L.) Dumort.–Humus, base of *Populus tremuloides, H1016.*

Brachythecium oxycladon (Brid.) Jaeg. & Sauerb.–Shaded and exposed dolomite, *H905.*

B. plumosum (Hedw.) B.S.G.–Exposed dolomite, *H1029.*

Bryoerythrophyllum recurvirostrum (Hedw.) Chen–Exposed dolomite, *H951*; shaded boulder face, *M4650.*

Bryum capillare Hedw.–Shaded humus at base of *Thuja, M4651.*

Campylium chrysophyllum (Brid.) J. Lange–Humus on ledge, *H948*; exposed dolomite, *H962*; surface of boulder, *M4652.*

C. hispidulum (Brid.) Mitt.–Shaded ledge, *H914.*

Chiloscyphus pallescens (Ehrh.) Dumort.–Exposed dolomite, *H999*; humus, base of *Populus tremuloides, H1015.*

Cololejeunea biddlecomiae (Aust.) Evans–Shaded dolomite, *H943*; moist boulder face, *M4641.*

Dicranum flagellare Hedw.–Rotting log, *M4653.*

D. scoparium Hedw.–Humus on ledge, *H940.*

Didymodon rigidulus Hedw.–Exposed dolomite, *H950.*

Distichium capillaceum (Hedw.) B.S.G.–Shaded and exposed dolomite, *H912;* face of shaded boulder, *M4654.*

Encalypta procera Bruch–Dry, exposed dolomite, *H904*; base of shaded ledge, *M4655.*

Eucladium verticillatum (Brid.) B.S.G.–Exposed dolomite, *H1028.*

Frullania eboracensis Gottsche–Shaded and exposed dolomite, *H935;* face of dry boulder, *M4642.*

Gymnostomum aeruginosum Sm.–Shaded dolomite, *H922*; face of shaded boulder, *M4656.*

Homomallium adnatum (Hedw.) Broth.–Exposed dolomite, *H979.*

Hypnum cupressiforme Hedw.–Exposed dolomite, *H986.*

Leskeella nervosa (Brid.) Loeske–Shaded dolomite, *H944*; dry ledge, *M4658.*

Lophocolea minor Nees–Shaded and exposed dolomite, *H938;* damp face of boulder, *M4643.*

Lophozia heterocolpos (Thed.) Howe–Exposed dolomite, *H903.*

Mnium orthorrhynchum Brid.–Humus on ledge, *H967.*

Myurella julacea (Schwaegr.) B.S.G.–Shaded ledge, *H913*; exposed dolomite, *H952*; crevice in boulder, *M4659A.*

M. sibirica (C. Müll.) Reim.–Exposed dolomite, *H917*; shaded boulder face, *M4659.*

Neckera pennata Hedw.–Exposed dolomite, *H958;* moist, shaded boulder face, *M4660.*

Oncophorus wahlenbergii Brid.–Rotting log, crest of ledge, *M4661.*

Orthotrichum anomalum Hedw.–Exposed dolomite, *H969;* face of dry dolomite block, *M4662;* top and sides of shaded boulder, *M4663.*

Plagiochila asplenioides (L.) Dumort.–Humus, shaded ledge, *H921;* damp boulder face, *M4645.*

Platydictya jungermannioides (Brid.) Crum–Side of shaded boulder, *M4647.*

Pleurozium schreberi (Brid.) Mitt.–Humus on ledge, *H1026.*

Pohlia nutans (Hedw.) Lindb.–Humus, base of boulder, *H939.*

Porella platyphylla (L.) Lindb.–Shaded and exposed dolomite, *H933.*

Preissia quadrata (Scop.) Nees–Crevice in ledge, *H1018.*

Radula complanata (L.) Dumort.–Shaded and exposed dolomite, *H931, 970;* ledge, *H946.*

Rhodobryum roseum (Hedw.) Limpr.–Humus over dolomite, *H956;* moist, shaded boulder, *M4664.*

Rhytidiadelphus triquetrus (Hedw.) Warnst.–Top of boulder, *M4665.*

Scapania gymnostomophila Kaal.–Exposed dolomite, *H994;* same, *H1030* (with *Lophozia heterocolpos*). Rare in Michigan, where apparently known previously from only Isle Royale (Nichols & Steere, 1936) and the Keweenaw Peninsula (Steere, 1942), this species has been collected more frequently at places around the west end of Lake Superior (Schuster, 1958). Williams (1968) reports it from several stations on the Bruce Peninsula, Ontario.

Thuidium recognitum (Hedw.) Lindb.–Shaded ledge, *H908;* exposed dolomite, *H988.*

Tortella fragilis (Hook. ex Drumm.) Limpr.–Shaded ledge, *H906.*

T. tortuosa (Hedw.) Limpr.–Shaded and exposed dolomite, *H910;* shaded ledge, *H920;* boulder face, *M4666.*

Moss-clogged springs flowing over dolomite pavement at head of a broad, open beach extending NW along shore from Summer Science Camp, shaded inland by *Thuja* thickets, NE shore of island, Sect. 22 and NW¼ Sect. 27 (T. 37 N., R. 19 W.), 16 July 1968.

Aulacomnium palustre (Hedw.) Schwaegr.–Wet soil near pool, *H1006;* organic debris, floor of thicket, *M4710.*

Blepharostoma trichophyllum (L.) Dumort.–Side of stump, *M4671 p. p.;* floor of thicket, *M4709 p. p.*

Brachythecium plumosum (Hedw.) B.S.G.–Moist ground bordering pool, *H1047.*

B. turgidum (C. J. Hartm.) Kindb.–Moist ground bordering pool, *H1046;* exposed, wet pavement, *M4681.*

Bryum pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb.–Standing water, *H972;* margin of pool, *H977;* water, edge of L. Michigan, *M4667;* submerged in spring water, *M4689.*

Calliergon giganteum (Schimp.) Kindb.–Moist ground bordering pool, *H1059;* emergent from pool, *M4703.*

Campylium polygamum (B.S.G.) C. Jens.–Moist soil bordering pool, *H1022.*

C. stellatum (Hedw.) C. Jens.–Wet, limy soil, *M4690;* organic debris, floor of thicket, *M4711.*

Chiloscyphus pallescens (Ehrh.) Dumort.–Humus under *Thuja, M4669;* thin organic turf over dolomite, *M4670.*

Climacium dendroides (Hedw.) Web. & Mohr–Wet soil near pool, *H1004;* organic debris, floor of thicket, *M4712.*

Cratoneuron filicinum (Hedw.) Spruce–Moist ground bordering pool, *H1021;* spring water, *M4682;* organic debris, floor of thicket, *M4713.*

Dicranum polysetum Sw.–Moist ground bordering pool, *H1024.*

Ditrichum flexicaule (Schwaegr.) Hampe–Moist soil near pool, *H1011;* organic debris, crevice in pavement, *M4704.*

Drepanocladus aduncus (Hedw.) Warnst.–Standing water, *H971;* emergent from spring pool, *M4683;* wet, limy soil over pavement, *M4691.*

D. revolvens var. *intermedius* (Lindb. ex C. J. Hartm.) Rich. & Wallace–Emergent from spring pool, *M4684;* wet, limy soil over pavement, *M4692;* submerged in shallow pool, *M4705.*

D. sendtneri (Schimp.) Warnst.–Semi-shaded spring water, *M4694.*

D. vernicosus (Lindb. ex C. Hartm.) Warnst.–Standing water, *H925.*

Fissidens osmundoides Hedw.–Organic debris, side of rotting log, thicket, *M4706.*

Geocalyx graveolens (Schrad.) Nees–Organic debris, floor of thicket, *M4707.*

Helodium blandowii (Web. & Mohr) Warnst.–Humus beneath *Abies, H1049.*

Hygroamblystegium tenax (Hedw.) Jenn.–Margin of pool, *H974.*

Hylocomium splendens (Hedw.) B.S.G.–Organic debris, floor of thicket, *M4715.*

Hypnum lindbergii Mitt.–Moist soil near pool, *H1110;* humus, floor of thicket, *M4716.*

Isopaches hellerianus (Nees) Buch–Underside of rotting log, thicket, *M4668.*

Jamesoniella autumnalis (DC.) Steph.–Organic turf on log, thicket, *M4697.*

Jungermannia leiantha Grolle [*J. lanceolata* of authors not L.; Grolle (Taxon 15: 186-191. 1966) has shown that of the material cited in Linnaeus' original description, none represents *J. lanceolata* of later workers. A new name for this common and widespread hepatic was therefore required.]–Moist soil bordering pool, *H1012 p. p.;* organic turf on log,

M4698; thin organic turf, stump side, *M4671 p. p., 4672* (some plants in both collections with erect gemmiparous shoot apices). The occurrence of gemmae in two of the cited specimens deserves some comment in view of Váňa's recent discussion (1969; see also Grolle & Váňa, 1969) of *J. subulata* Evans (*J. amakawana* Grolle), a closely related species which characteristically has erect gemmae-bearing shoots similar to those less frequently found in *J. leiantha.* Although only recently recognized as such *(ibid.), J. subulata* is apparently widely distributed in the Northern Hemisphere (viz. Hawaii, Japan, Korea, northern and southern India, the Caucasus, eastern and central Europe, and North America–Minnesota, Wisconsin, Missouri). It is dioecious in contrast to the paroecious, rarely autoecious, *J. leiantha.* Certain other characters mentioned by Váňa (1969), such as leaf shape (oval to orbicular in *J. subulata* vs. longer than broad in *J. leiantha*) and leaf-middle cell size (30-35 × 35-45 μ in *J. subulata* vs. 35-40 × 45-50 μ in *J. leiantha*), are, in our experience, too variable to be of much help in identification. Although the difference in chromosome number (n = 17 in European plants of *J. leiantha* and n = 9 in Japanese material of *J. subulata*) is clearly significant, confirmatory counts from other places where these widely distributed species occur should be obtained. The total range of *J. subulata* in North America has not yet been determined, but at present it is known to occupy similar habitats and to be mostly coextensive with *J. leiantha.*

Lepidozia reptans (L.) Dumort.–Moist soil bordering pool, *H1012 p. p.*

Lophocolea minor Nees–Thin organic turf on pavement, *M4673.*

Lophozia heterocolpos (Thed.) Howe–Thin organic turf on boulder, *M4674.*

L. incisa (Schrad.) Dumort.–Side of rotting log, thicket, *M4699.*

L. porphyroleuca (Nees) Schiffn.–Same, *M4700.*

Marchantia polymorpha L.–On organic debris among sedges, exposed pavement, *M4675.*

Mnium affine Bland ex Funck–Moist soil near pool, *H1009.*

M. orthorrhynchum Brid.–Humus, floor of thicket, *H929.*

Philonotis fontana (Hedw.) Brid.–Margin of pool, *H1002;* among sedges, spring water, *M4687.*

Plagiochila asplenioides (L.) Dumort.–Humus on pavement, *M4708.*

Preissia quadrata (Scop.) Nees–Dolomite cobble near shore, *M4676.*

Ptilidium pulcherrimum (Web.) Hampe–Stump side, thicket, *M4671 p. p.*

Rhytidiadelphus triquetrus (Hedw.) Warnst.–Humus, floor of thicket, *H928.*

Riccardia pinguis (L.) S. F. Gray–Organic debris, floor of thicket, *M4709 p. p.*

Scapania gymnostomophila Kaal.–Thin organic turf over pavement, semi-shade, *M4677.*

S. nemorosa (L.) Dumort.–Rotting log, thicket, *M4702.*

Sphagnum capillaceum (Weiss) Schrank–Floor of thicket, *M4717.*

Thuidium delicatulum var. *radicans* (Kindb.) Crum, Steere & Anderson–Humus, floor of thicket, *H927.*

T. recognitum (Hedw.) Lindb.–Wet soil near pool, *H1005.*

Tomenthypnum nitens (Hedw.) Loeske–Moist ground bordering pool, *H1013;* humus, floor of thicket, *M4718.*

Tortella fragilis (Hook. ex Drumm.) Limpr.–Exposed boulder, *M4688;* wet, limy sand, *M4695.*

Low dolomite ledge within reach of large waves, along shore near N end of island, just E of Gravel Point, Sect. 21 (T. 37 N., R. 19 W.), 16 July 1968.

Fissidens osmundoides Hedw.–Organic turf, crevice, *M4719 p. p.*

Lophozia collaris (Nees) Schust.–Same, *M4719 p. p.*

Mnium marginatum (With.) Brid. ex P. Beauv.–Same, *M4719 p. p.*

Dry *Thuja* forest, inland from NE shore of island, Sect. 21 (T. 37 N., R. 19 W.), 16 July 1968.

Bazzania trilobata (L.) S. F. Gray–Soil, forest floor, *H1050;* organic debris, base of stump, *M4720.*

Geocalyx graveolens (Schrad.) Nees–Humus, forest floor, *H1056.*

Hypnum lindbergii Mitt.–Decaying log, *H1037.*

H. pallescens (Hedw.) P. Beauv.–Same, *H978.*

Jungermannia leiantha Grolle–Humus, base of *Thuja, H1057.*

Lepidozia reptans (L.) Dumort.–Same, *H1058 p. p.*

Leucobryum glaucum (Hedw.) Ångstr. ex Fr.–Soil, forest floor, *H1051.*

Lophozia incisa (Schrad.) Dumort.–Decaying log, *H1060.*

Plagiothecium laetum B.S.G.–Soil, base of tree, *H1048.*

Ptilium crista-castrensis (Hedw.) De Not.–Decaying log, *H1032.*

Thuidium recognitum (Hedw.) Lindb.–Soil, forest floor, *H1053.*

Beach at Summer Harbor, Sect. 27 (T. 37 N., R. 19 W.), 16 July 1968.

Bryum argenteum Hedw.–Sand, *M4721.*

Acer saccharum–Fagus grandifolia forest transected by a low, dry dolomite ledge, near center of island, Sect. 27 (T. 37 N., R. 19 W.), 17 July 1968.

Amblystegium varium (Hedw.) Lindb.–Bark of living *Acer, M4727.*

Anomodon minor (Hedw.) Fürnr.–Humus, tree base, *H1146.*

Brachythecium oxycladon (Brid.) Jaeg. & Sauerb.–Humus, forest floor, *H1114.*

Brotherella recurvans (Michx.) Fleisch.–Humus, tree base, *H1095.*

Bryhnia novae-angliae (Sull. & Lesq. ex Sull.) Grout–Dry ledge, *M4728.*

Conocephalum conicum (L.) Dumort.–Damp soil, trailside bank, *H1119, M4722.*

Dicranella heteromalla (Hedw.) Schimp.–Humus, forest floor, *H1111.*

Dicranum scoparium Hedw.–Forest floor, *M4729.*

Eurhynchium pulchellum (Hedw.) Jenn.–Decaying log, *H1143.*

Fissidens cristatus Wils. ex Mitt.–Humus, forest floor, *H1113.*

Frullania bolanderi Aust.–Bark of living *Acer, H1121, M4723.*

F. brittoniae Evans–Same, *M4725.*

F. eboracensis Gottsche–Tree bark, *H1149.*

Heterophyllium haldanianum (Grev.) Kindb.–Decaying log, *H1132.*

Leucodon sciuroides (Hedw.) Schwaegr.–Tree bark, *H1087 p. p.*

Mnium affine Bland ex Funck–Humus, forest floor, *H1110;* humus, tree base, *H1144.*

Orthotrichum obtusifolium Brid.–Tree bark, *H1087 p. p.*

O. sordidum Sull. & Lesq. ex Aust.–Same, *H1087 p. p.*

Plagiopus oederiana (Sw.) Limpr.–Ledge, *H1089, M4730.*

Platydictya confervoides (Brid.) Crum–Ledge, *H1088.*

P. subtile (Hedw.) Crum–Humus, tree base, *H1147 p. p.*

Platygyrium repens (Brid.) B.S.G.–Tree bark, *H1148;* bark of living *Acer, M4731.*

Polytrichum ohioense Ren. & Card.–Forest floor, *H1120.*

Porella platyphylla (L.) Lindb.–Humus, tree base, *H1145;* bark of living *Acer, M4726.*

Radula complanata (L.) Dumort.–Humus, tree base, *H1147 p. p.*

Rhodobryum roseum (Hedw.) Limpr.–Ledge, *H1086.*

Dry *Thuja* stand inland from SW shore of island, Sect. 33 (T. 37 N., R. 19 W.), 17 July 1968.

Blepharostoma trichophyllum (L.) Dumort.–Rotting log, *H1076.*

Bryum capillare Hedw.–Dry soil, *M4732.*

Dicranum polysetum Sw.–Humus, forest floor, *H1067.*

D. scoparium Hedw.–Same, *H1100.*

Jamesoniella autumnalis (DC.) Steph.–Rotting log, *H1077, M4733.*

Mnium orthorrhynchum Brid.–Humus, forest floor, *H1066.*

Thuidium recognitum (Hedw.) Lindb.–Same, *H1098.*

Moist *Thuja* thicket at head of a broad cobblestone beach, near S end of island, Sect. 3 (T. 36 N., R. 19 W.), 17 July 1968.

Brachythecium oxycladon (Brid.) Jaeg. & Sauerb.–Dry rock, edge of beach, *M4742.*

Catoscopium nigritum (Hedw.) Brid.–Sand and gravel, head of beach, *M4743.*

Cephalozia media Lindb.–Rotting log, thicket, *M4740 p. p.*

Cephaloziella sullivantii (Aust.) Evans–Rotting log, thicket, *M4738.*

Dicranum montanum Hedw.–Dry log in shade, thicket, *M4744.*

Fissidens osmundoides Hedw.–Rotting log, thicket, *M4745.*

Funaria hygrometrica Hedw.–Soil, beach, *H1139.*

Hygrohypnum luridum (Hedw.) Jenn.–Exposed rock, head of beach, *M4746.*

Hypnum pratense Koch ex Spruce–Litter, floor of thicket, *M4741.*

Isopaches hellerianus (Nees) Buch–Rotting log, thicket, *M4735 p. p.*

Isopterygium turfaceum (Lindb.) Lindb.–Decaying wood, thicket, *H1122.*

Leskeella nervosa (Brid.) Loeske–Top of boulder, beach, *M4747.*

Lophozia porphyroleuca (Nees) Schiffn.–Rotting log, thicket, *M4739.*

Meesia uliginosa Hedw.–Humus on log, thicket, *M4748.*

Nowellia curvifolia (Dicks.) Mitt.–Rotting log, thicket, *M4735 p. p.*

Riccardia latifrons Lindb.–Same, *H1124, M4735 p. p.*

R. multifida (L.) S. F. Gray–Humus, floor of thicket, *M4736.*

R. palmata (Hedw.) Carruth.–Rotting log, thicket, *M4737.*

Tetraphis pellucida Hedw.–Same, *M4749.*

Weissia controversa Hedw.–Soil, exposed beach, *H1140.*

Dry, ± shaded dolomite blocks and ledges along shore near S end of island, Sect. 3 (T. 36 N., R. 19 W.), 17 July 1968.

Cololejeunea biddlecomiae (Aust.) Evans–Ledge, *M4751.*

Homomallium adnatum (Hedw.) Broth.–Exposed dolomite, *H1069.*

Hypnum cupressiforme Hedw.–Exposed dolomite, *H1068.*

Lejeunea cavifolia (Ehrh.) Lindb.–Over mosses, side of shaded block, *M4752.*

Leucodon sciuroides (Hedw.) Schwaegr.–Exposed dolomite, *M1073.*

Mnium spinulosum B.S.G.–Humus, crest of ledge, *M4754.*

Radula complanata (L.) Dumort.–Side of block, *M4753.*

Tortula ruralis (Hedw.) Gaertn., Meyer & Scherb.–Dry boulder, *M4755.*

Exposed dolomite pavement, low dolomite ledges, and spring flowing over bedrock, along SE and E shores of island, Sects. 34 and 35 (T. 37 N., R. 19 W.), 17 July 1968.

Anomodon rostratus (Hedw.) Schimp.–Exposed dolomite, *H1189.*

Brachythecium oxycladon (Brid.) Jaeg. & Sauerb.–Humus, marshy shore, *H1134.*

B. turgidum (C. J. Hartm.) Kindb.–Moist soil near spring, *H1062;* organic debris, shaded head of spring, *M4760.*

Bryoerythrophyllum recurvirostrum (Hedw.) Chen–Soil, rock shore, *H1136 p. p.*

Catoscopium nigritum (Hedw.) Brid.–Soil, edge of beach pool, *H1138;* solution pits in pavement, *M4757.*

Ceratodon purpureus (Hedw.) Brid.–Soil, rocky shore, *H1137.*

Dicranum scoparium Hedw.–Humus, ledge, *H1096.*

Didymodon rigidulus Hedw.–Crevice, ledge, *M4757.*

Distichium capillaceum (Hedw.) B.S.G.–Humus along shore, *H1083;* ledge, *H1093.*

Ditrichum flexicaule (Schwaegr.) Hampe–Moist soil near spring, *H1063;* humus, edge of beach pool, *H1065.*

Drepanocladus revolvens var. *intermedius* (Lindb. ex C. J. Hartm.) Rich. & Wallace–Spring water, *M4761.*

Fissidens adiantoides Hedw.–Soil, rocky shore, *H1135.*

F. cristatus Wils. ex Mitt.–Ledge, *H1102.*

Gymnostomum recurvirostrum Hedw.–Solution pits in pavement, *M4759.*

Lejeunea cavifolia (Ehrh.) Lindb.–Ledge, *M1109.*

Lophocolea minor Nees–Humus along shore, *H1084.*

Orthotrichum anomalum Hedw.–Exposed limestone, *H1190.*

Plagiochila asplenioides (L.) Dumort.–Soil, pool margin, *H1090.*

Scorpidium turgescens (T. Jens.) Loeske–Moss-clogged spring over pavement, *H1151.* An apparently uncommon species in Michigan where known otherwise from near Charlevoix (Charlevoix Co.), Drummond Island (Chippewa Co.), and Bois Blanc Island (Mackinac Co.), all strongly calcareous sites. This species is near its southern limit of range in the Great Lakes region.

Tortella fragilis (Hook. ex Drumm.) Limpr.–Soil, rocky shore, *H1136.*

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THE DISTRIBUTION OF MOSSES IN THE BYRON BOG, SOUTHWESTERN ONTARIO

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The Byron Bog is a *Sphagnum-Chamaedaphne* bog situated in the northwest part of the City of London, southwest of the intersection of Oxford Street and the Hyde Park Sideroad. It occupies a poorly drained depression about 15 ha (37 acres) in extent.

Judd (1957) has published a description and map of the bog. He divides it into four vegetation zones:

Zone A is a mat of floating Sphagnum densely covered in many areas with leatherleaf, *Chamaedaphne calyculata* (L.) Moench, and with a few small scattered larch, *Larix laricina* (Du Roi) K. Koch, and black spruce, *Picea mariana* (Mill.) BSP.

Zone B consists of low woods permanently damp and often flooded. For convenience I have divided this zone into two sub-zones:

B1–adjacent to zone A and with larger larch and black spruce over leatherleaf and other shrubs. Dense thickets of alder-buckthorn, *Rhamnus frangula* L., are common. *Sphagnum* occurs throughout, forming a dense mat at the inner, more open edge, and occurring in more local patches or hummocks in the more shaded and slightly drier inner parts.

B2–contains moisture-tolerant trees such as silver maple, *Acer saccharinum* L., white pine, *Pinus strobus* L., and white birch, *Betula papyrifera* Marsh. Alder-buckthorn forms dense thickets in many parts.

Zone C is the wooded drier slopes about the depression supporting a variety of deciduous trees and shrubs.

Zone D is the pond in the centre of zone A.

More complete descriptions are given in Judd's paper, and in a series of subsequent studies on the distribution of several plant groups in the bog: shrubs and vines (Judd, 1966), club-mosses and ferns (Judd, 1967), orchids (Judd, 1968), and *Sphagnum* mosses (Judd, 1969).

Mosses were collected from many parts of zones A and B between May 1 and October 6, 1969. Two visits were made in May, one in June, one in August, two in September, and one in October. Little collecting was done on the dry slopes (Zone C); the moss flora is relatively sparse here and is very similar to that of nearby deciduous woods.

A few other records are included, particularly those of Matthew Mukkattu who collected during the summer of 1969. Records, other than the author's, can rarely be assigned to a particular zone.

The Sphagnobrya are not included; collections of the author and others have added no further taxa to Judd's list (1969).

All records are substantiated by specimens in the herbarium of the University of Western Ontario (UWO); the accession numbers apply to those collected by the author. The nomenclature and arrangement follow Crum, Steere, and Anderson (1965). I am indebted to Dr. Howard Crum for advice and for identifying many of the more difficult taxa.

Ditrichum pallidum (Hedw.) Hampe–Zone B2: on soil, M. Mukkattu, July, 1969.

Ceratodon purpureus (Hedw.) Brid.–Zone B1: on humus (with *Heterophyllium haldianum*), 235; on wet humus, 288.

Dicranella heteromalla (Hedw.) Schimp.–on soil (with *Mnium affine*), M. Mukkattu, June 5, 1969.

Dicranum bonjeanii De Not. ex Lisa–on soil, M. Mukkattu, June 5, 1969.

Dicranum montanum Hedw.–common on tree trunks in zone B2: on white birch (with *Heterophyllium haldianum* and *Plagiothecium denticulatum*), 243; on red maple, 245; on white birch (with *Hypnum pallescens* and *Ptilidium pulcherrimum*), 246.

Dicranum polysetum Sw.–Zone B1: on peat (with *Aulacomnium palustre* and *Sphagnum* sp.), 464. On peat soil, M. Mukkattu, July 29, 1969. J. B. Phipps, Nov. 11, 1961.

Dicranum scoparium Hedw.–Zone A: on peat (with *Sphagnum* sp.), 290. Zone B1: on soil, 228.

Dicranum undulatum Brid.–on soil, M. Mukkattu, June 5, 1969.

Funaria hygrometrica Hedw.–Zone B2: on damp ashes, 250.

Tetraphis pellucida Hedw.–Common on wood. Zone B1: on larch buttress (with *Heterophyllium haldianum* and *Pohlia nutans*), 320. Zone B2: on rotting stump, 225.

Pohlia nutans (Hedw.) Lindb.–Zone B1: on larch buttress (with *Heterophyllium haldianum* and *Tetraphis pellucida*), 320.

Bryum argenteum Hedw.–Zone B2: on black humus and old cinders, 248.

Bryum pseudotriquetrum (Hedw.) Gaertn., Meyer, & Scherb.–Zone B1: on peat soil, 230.

Mnium affine Bland. ex Funck–on soil (with *Dicranella heteromalla*), M. Mukkattu, June 5, 1969.

Mnium cuspidatum Hedw.–Zone B2: on humus (with *Aulacomnium palustre, Brachythecium rutabulum,* and *Heterophyllium haldianum*), 224; on humus, 226.

Mnium punctatum Hedw. var. *elatum* Schimp.–Zone B1: on damp humus, 577.

Aulacomnium palustre (Hedw.) Schwaegr.–common in all wetter areas. Zone A: on peat (with *Sphagnum* spp.), 286. Zone B1: on peat (with *Sphagnum* spp.), 284; on peat (with *Dicranum polysetum* and *Sphagnum* spp.), 464.

Zone B2: on rotting wood (with *Brachythecium rutabulum, Heterophyllium haldianum* and *Mnium cuspidatum*), 224; on exposed roots (with *Heterophyllium haldianum,* and *Hypnum pallescens*), 324; on decaying leaves, 329.

Climacium dendroides (Hedw.) Web. & Mohr—Zone B1: on soil, 233; on black humus (with *Polytrichum formosum* var. *aurantiacum*), 333. Zone B2: on decaying log (with *Amblystegium juratzkanum, Leptodictyum riparium,* and *L. trichopodium*), 461; on humus, 462.

Leskea gracilescens Hedw.—Zone B2: on bark of *Salix* sp., 406.

Leskea polycarpa Hedw.—Zone B2: on decaying branch (with *Heterophyllium haldianum*), 325.

Thuidium delicatulum (Hedw.) B.S.G.—Zone B1: on soil and hummocks, 578.

Cratoneuron filicinum (Hedw.) Spruce—Zone A: on very wet humus (with *Calliergon cordifolium, Drepanocladus fluitans,* and *Leptodictyum trichopodium*), 463.

Campylium radicale (P. Beauv.) Grout—Zone B1: on black humus (with *Calliergon cordifolium* and *Drepanocladus fluitans*), 466. Zone B2: on humus, 221.

Leptodictyum riparium (Hedw.) Warnst.—Zone B2: on decaying log (with *Amblystegium juratzkanum, Climacium dendroides,* and *Leptodictyum trichopodium*), 461.

Leptodictyum trichopodium (Schulz) Warnst.—Zone A: on very wet humus (with *Calliergon cordifolium, Cratoneuron filicinum,* and *Drepanocladus fluitans*), 463. Zone B2: on black humus, 407; on decaying log (with *Amblystegium juratzkanum, Climacium dendroides,* and *Leptodictyum riparium*), 461.

Amblystegium juratzkanum Schimp.—Zone B2: on decaying log (with *Climacium dendroides, Leptodictyum riparium,* and *L. trichopodium*), 461.

Amblystegium varium (Hedw.) Lindb.—Zone B2: low on elm trunk, 254; low on trunk of poplar, 398.

Drepanocladus fluitans (Hedw.) Warnst.—Abundant in wetter areas of zones A and B1. Zone A: on very wet humus (with *Calliergon cordifolium, Cratoneuron filicinum,* and *Leptodictyum trichopodium*), 463. Zone B1: on black humus, 332, 402; on black humus (with *Calliergon cordifolium* and *Campylium radicale*), 466.

Drepanocladus uncinatus (Hedw.) Warnst.—Zone B1: on soil, 251.

Hygrophypnum luridum (Hedw.) Jenn.—Zone A: on peat at edge of zone D (pond) with *Calliergon cordifolium*), 399.

Calliergon cordifolium (Hedw.) Kindb.—Abundant in very wet areas of zones A and B1. Zone A: on peat at edge of zone D (with *Hygrohypnum luridum*), 399; on very wet humus (with *Cratoneuron filicinum, Drepanocladus fluitans,* and *Leptodictyum trichopodium*) 463. Zone B1: on very wet humus (with *Campylium radicale* and *Drepanocladus fluitans*), 466.

Brachythecium rutabulum (Hedw.) B.S.G.–Zone B2: on black humus (with *Cirriphyllum piliferum*), 222; on decaying branches (with *Heterophyllium halidianum*), 224; on humus and roots (with *Plagiothecium denticulatum*), 289.

Brachythecium salebrosum (Web. & Mohr) B.S.G.–Zone B1: on dead branch over *Sphagnum* sp., 231.

Cirriphyllum piliferum (Hedw.) Grout–Zone B2: on black humus (with *Brachythecium rutabulum*), 222.

Eurhynchium hians (Hedw.) Sande Lac.–Zone B2: on soil, 588.

Pleurozium schreberi (Brid.) Mitt.–Zone B1: on humus, 400.

Plagiothecium denticulatum (Hedw.) B.S.G.–Zone B2: on black humus, 220; on buttress of white birch (with *Heterophyllium haldianum* and *Dicranum montanum*), 243; on humus and roots (with *Brachythecium rutabulum*), 289.

Plagiothecium laetum B.S.G.–Zone B2: low on yellow birch trunk (with *Isopterygium turfaceum*), 328; on fallen logs, M. Mukkattu, Aug. 6, 1969.

Heterophyllium haldianum (Grev.) Kindb.–Very abundant throughout zone B. Zone B1: on humus (with *Ceratodon purpureus*), 235; on decaying black spruce stump, 241. Zone B2: on fallen decayed logs and branches (with *Aulacomnium palustre, Brachythecium rutabulum, Leskea polycarpa,* and *Mnium cuspidatum*), 223, 224, 247, 325, 326; on buttress of silver maple (with *Hypnum pallescens*), 242; on buttress of white birch (with *Dicranum montanum* and *Plagiothecium denticulatum*), 243; on buttress and exposed roots of larch (with *Aulacomnium palustre, Hypnum pallescens, Pohlia nutans,* and *Tetraphis pellucida*), 320, 324.

Brotherella recurvans (Michx.) Fleisch.–Zone B2: low on larch trunk, 244; on rotting stump (with *Isopterygium turfaceum*), 405.

Platygyrium repens (Brid.) B.S.G.–Abundant on bark of many deciduous trees in zones B2 and C. Zone C: on butternut, 249.

Hypnum imponens Hedw.–Zone B2: on damp humus over exposed roots, 584.

Hypnum pallescens (Hedw.) P. Beauv.–Zone B2: low on silver maple trunk (with *Heterophyllium haldianum*), 242; low on white birch trunk (with *Dicranum montanum*), 246; on exposed larch root (with *Aulacomnium palustre* and *Heterophyllium haldianum*), 324.

Isopterygium turfaceum (Lindb.) Lindb.–Zone B2: low on yellow birch trunk (with *Plagiothecium laetum*), 328; on rotting stump (with *Brotherella recurvans*), 405.

Atrichum undulatum (Hedw.) P. Beauv.–Collector unknown, Nov. 8, 1941.

Polytrichum commune Hedw.–Zone B1: on peat (with *Sphagnum* sp.), 404.

Polytrichum formosum Hedw. var. *aurantiacum* (Hoppe ex Funck) C. J. Hartm.–Zone B1: on black humus (with *Climacium dendroides*), 333.

Polytrichum juniperinum Hedw.–Common at inner edge of zone B1: on peat (with *Sphagnum* spp.), 285, 415, 465.

Of the 43 moss taxa assigned to zones in the bog, 60% were found in zone B2, 47% in B1, and 19% in A. Only 5 mosses were common to zones A and B1, 5 were common to B1 and B2, only one was found in both A and B2, and only one (*Aulacomnium palustre*) was found in all three zones.

Only a few species compete with the Sphagnums in zone A; the most successful are *Aulacomnium palustre* and *Polytrichum juniperinum.* Most of the other mosses of zone A are semi-aquatic Amblystegiaceae growing in tangles of several species on the edges of zone D and other small ponds.

Competition from Sphagnums is still severe in much of zone B1, but becomes less so adjacent to zone B2 where several species found on humus and decaying wood are added. Zone B2 provides the variety of habitats and moist, cool conditions optimum for many moss species. Several semi-aquatics are still found in wet depressions and many more soil- and wood-inhabiting species occur. The bark of the several species of dedicuous trees provides most of the corticolous forms found in the bog.

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THE BIOSYSTEMATICS AND ECOLOGY OF THE GENUS *BRACHYELYTRUM* (GRAMINEAE) IN MICHIGAN

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INTRODUCTION

Brachyelytrum Beauv. is a monotypic grass genus of the deciduous and mixed conifer-hardwood forests of eastern North America and eastern Asia. The phylogenetic position of the genus is obscure; however, most recent classification schemes place it in the monotypic tribe Brachyelytreae in the temperate subfamily Festucoideae (Stebbins & Crampton, 1961; Gould, 1968).

Current taxonomic treatments of North American populations place them in a single species, *B. erectum* (Schreb.) Beauv., within which some authorities have recognized differentiation at the infraspecific level (Babel, 1943; Koyama & Kawano, 1964). Not all recent workers, however, have recognized infraspecific taxa, nor has there been complete agreement on criteria among those who do.

As is the case with other forest-dwelling Gramineae, little is known about the ecology of *Brachyelytrum.* Pohl (1947) and Fassett (1951) indicate that the two recognized varieties [*B. erectum* var. *erectum* and *B. erectum* var. *septentrionale* Babel] possess differing phytogeographic affinities and perhaps differ ecologically. The areas of the two varieties are shown by Pohl and Fassett to overlap in Pennsylvania and Wisconsin, but they show that the zone of overlapping distribution is narrow relative to the area of either taxon. A more complete assessment of the distribution of the taxa is difficult since the areas of both taxa are only partially known. Although it might be expected, no mention is made of intergradation where the two taxa are sympatric.

During the course of field work in Lower Michigan the two taxa were found growing in the same woodlot, with many populations only a few meters apart and growing under apparently identical conditions. This observation suggested that differentiation within *B. erectum* has progressed further than has heretofore been recognized taxonomically. My objective in this study has been to determine the relationship between the two taxa (in Michigan) through an examination of their phenetic variation, ecology, and geographical distribution.

DESCRIPTION AND TAXONOMY

Brachyelytrum is a strongly perennial, cespitose grass which spreads vegetatively by means of short rhizomes. Innovations are borne both terminally and laterally or, less commonly, may arise from the basal nodes of the previous season's culms. Perennating culm buds are invested in 6 to 10

prophylls of which the uppermost elongate as the culm elongates. The lowermost leaf blade is greatly reduced, ranging from < 0.5 cm to 2.0 cm in length and to 1.3 cm in width. An additional 5 to 7 leaves are produced in which there is a gradual increase in length/width ratio from the lower to the uppermost. In general, the third and fourth sub-terminal leaves are the largest, ranging from 7 to 18 cm in length and to 2.5 cm in width.

The inflorescences are solitary, terminal panicles[1] in which the spikelets are borne singly, either subsessile or on short pedicels. Both glumes are present, although the lower is often greatly reduced or rudimentary. Glume size is closely related to position of the spikelet in the inflorescence; glumes subtending basal spikelets are generally larger than those subtending terminal spikelets. The single-flowered spikelets possesses a long-awned lemma, a well developed two-toothed palea, and a rachilla extension which is approximately three-quarters the length of the palea. The lemma is weakly to strongly nerved and bears a vestiture of single-celled hairs which, excluding callus hairs, vary from < 0.1 to 0.7 mm in length. As with the glumes, spikelet characters vary predictably with position in the inflorescence, decreasing in size in an acropetal direction.

Vestiture of the culms and leaves is variable. Where pubescence is most highly developed in both density and extent it is generally spreading and the leaves densely ciliate. Where pubescence is least developed it is appressed and marginal cilia on leaves are much reduced in density or lacking altogether.

Babel (1943) recognized two infraspecific taxa, referring plants with spikelet pubescence > 0.2 mm in length to var. *erectum,* and plants with scabrous to glabrous spikelets (pubescence < 0.2 mm) to var. *septentrionale.* This treatment was followed by Fernald (1950) and others. Other treatments, e.g., Hitchcock (1951) and Gleason and Cronquist (1963) recognize no infraspecific differentiation. Most recently, Koyama and Kawano (1964) recognized North American populations as the subspecies *erectum,* including two varieties: var. *erectum* and var. *glabratum* (Vasey) Koyama & Kawano. Rather than lemma pubescence, they stress differences between lemma size and shape, inflorescence branching, and leaf and glume size.

Chromosome numbers for both North American taxa have been reported as 2n = 22 (Brown, 1950; Bowden, 1960). These numbers were also found in root-tip squash preparations from seedlings representing several Michigan populations. These cytological investigations, made during the course of this study, demonstrated no obvious differences between genomes of the two taxa. However, the investigations were preliminary and no karyotype analysis was attempted.

MATERIALS AND METHODS

Living and pressed materials from mass or population collections from 11 Lower Michigan *Brachyelytrum* populations were used in the initial phases

[1]All grass inflorescences are determinate and therefore cymose; however, convention is herein adhered to and the term panicle is used, albeit erroneously so (cf. Gould, 1968).

of this study. Table 1 gives pertinent details about the collection sites. Inter-population comparisons were made using measurements of anther [AL], palea [PL], rachilla extension [RE], awn [AWN L], and upper glume [UG] lengths, length of lemma pubescence [LV], and density of leaf cilia [LM]. Palea and rachilla extension lengths were measured from the point of articulation of the spikelet to the apex of the respective structures. Awn lengths were measured from the tip of the palea teeth to the awn apex. Leaf cilia numbers were determined from counts on 0.5 cm segments of both margins of third sub-terminal leaves; the derived values were expressed as the mean of these two counts. Length of lemma pubescence was measured on the central nerve at a point 5 mm above the basal constriction of the spikelet. Length measurements were made with calipers graduated to 0.05 mm. Anther data, except where noted, were taken from materials collected 1 to 3 days after anthesis and which were preserved in 70 percent EtOH.

In order to assess the influence of environmental differences on the morphology and development of *Brachyelytrum* from markedly dissimilar habitats, ramets from several clones (clumps) from northern and southern populations were obtained for field and greenhouse transplant studies. Field

TABLE 1. Location and habitat type from which mass collection materials were obtained.

Locality	Habitat type
Berrien Co., Warren Woods State Park. (R20W, T7S, S27).	Sugar maple-beech forest. Understory typical of mesic hardwood forests of southern Michgian.
Kalamazoo Co., Goose Lake. (R11W, T4S, S34).	Lake margin in mixed, mesic woodland; and in moist depressions of adjacent oak dominated uplands.
Conrad Bog. (R11W, T3S, S28).	Moist depressions in oak woodland adjacent to sphagnous bog. Understory typical of acid-sandy soils.
Calhoun Co., Uldriks Drive. (R8W, T1S, S18).	Old second-growth red oak forest. Understory typical of mesic uplands forests of southern Michigan.
Barry Co., Otis Lake. (R9W, T3N, S30).	Second growth (?) mixed oak forest. Understory variable, with elements of mesic forests and dry oak forest intermixed.
Ingham Co., Newman Road. (R1W, T4N, S24).	Old second-growth red oak-beech woods adjacent to sphagnous lowlands. Understory typical of mesic woods.
Baker Woodlot, Michigan State University campus.	Old sugar maple-beech forest. Understory typical of mesic woodland.
Lapeer Co., Flint River flood-plain. (R9E, T9N, S36).	Margin of flood plain; overstory of birch, aspen, and white pine. Understory typical of boreal lowlands and sphagnous bogs.
Roscommon Co., Canoe Camp Road. (R4W, T21N, S22).	Moist depressions in jack pine-oak uplands and margin of balsam-spruce-white cedar lowlands. Understory typical of boreal lowlands or bogs.
Crawford Co., Hartwick Pines State Park. (R3W, T27N, S10).	Moist depression under birch, beech, and aspen. Understory essentially lacking.

transplants were made into Baker Woodlot on the Michigan State University campus using 2 ramets for several clones from each locality. Growth and development of these plants were then compared with the corresponding *in situ* ramets.

Greenhouse materials, after potting, were allowed to acclimate for 1 week in a cool room before being transferred to a 70° F. growth room. A standard potting soil was used, into which the transplant, including the forest soil adhering to the root system, was placed. No light augmentation was employed; thus, photoperiods were considerably shorter than those of a normal growing season.

RESULTS AND DISCUSSION

ANALYSIS OF PHENETIC CHARACTERS

Three of the seven characters measured, AL, LV, and LM, emerged as a completely inter-correlated, non-overlapping character set separating the 11 populations into two distinct groups (Table 2). Plants with the combination of a) AL $\geqslant$ 5 mm, b) LV $\geqslant$ 0.5 mm, and c) low values of LM ($<$ 10 cilia/ 0.5 cm of leaf margin) are referrable to *Brachyelytrum erectum* var. *erectum.* Plants with a) AL $\leqslant$ 4 mm, b) LV $\leqslant$ 0.2 mm, and c) high values of LM ($>$ 15 cilia/ 0.5 cm of leaf margin) are referable to var. *septentrionale.* For convenience these varietal epithets will be applied to plants with the appropriate combination of characters as outlined above.

Of the remaining characters measured, AWN L was unique in that it exhibited no correlation with other characters, nor were there significant differences between taxa. Other spikelet measurements, PL, RE, and UG, differed significantly between the taxa, but overlapped to varying degrees. The various spikelet measurements represent a sample from all positions in the inflorescence. Since spikelet size was noted to decrease in an acropetal direction, the variance, and thus the degree of overlap, might have been reduced had the sample measurements been standardized at a specific position.

The only detailed phenetic comparison of varieties is that presented by Koyama and Kawano. In general the results of my phenetic analysis agrees with theirs; however, several incongruities were noted. They reported non-overlapping ranges of lemma lengths for the two taxa (although their table and text figures are inconsistent). I used palea length in preference to lemma length, as measurements of the palea can be made with more precision. Nonetheless, the two parameters are reasonably comparable, and in all cases ranges of measurements from the Michigan populations overlapped. Moreover, compared to their var. *glabratum,* Koyama and Kawano reported lower glumes to be more frequently obsolete in var. *erectum.* They also noted that upper glumes of var. *erectum* were, in general, shorter than those of var. *glabratum.* Neither condition was found to be the case in the Michigan material.

In order to test the constancy of LV and LM, additional data were obtained from herbarium[2] specimens representing approximately 60 individual

[2]Specimens examined are preserved in the following herbaria: Cranbrook Institute of Science, Michigan State University, and University of Michigan.

TABLE 2. Morphological characteristics of eleven Michigan *Brachyelytrum* populations. Measurements are expressed as mean ± standard error; lengths are expressed in mm.

Locality	A L[a]	L V	L M	P L	AWN L	R E	U G
Berrien Co., Warren Woods.	5.52±0.10	0.52±0.009	4.30 ±0.6	11.1±0.1	17.6±0.5	7.45±0.13	2.19±0.14
Kalamazoo Co., Goose Lake.	5.05±0.30	⩾0.5	4.75±1.0	9.8±0.1	24.9±0.5	6.80±0.10	2.23±0.17
Calhoun Co., Uldriks Drive.	6.34±0.70	⩾0.5	4.31±1.1	11.2±0.2	21.7±0.3	8.30±0.05	2.73±0.19
Barry Co., Otis Lake.	5.9[b]	⩾0.5	6.37±1.3	11.1±0.1	16.7±0.3	7.80±0.08	3.05±0.29
Ingham Co., Newman Road (I).	5.74±0.10	⩾0.5	4.35±1.3	11.8±0.1	16.4±0.3	7.60±0.07	3.40±0.18
Ingham Co., Baker Woods	5.71±0.12	⩾0.5	0.98±0.9	11.4±0.1	16.7±0.5	8.10±0.08	–
Kalamazoo Co., Conrad Bog.	3.54±0.03	⩽0.2	32.19±1.2	9.6±0.1	18.9±0.4	5.60±0.05	1.75±0.09
Ingham Co., Newman Road (II)	3.70±0.06	⩽0.2	22.04±1.0	10.2±0.2	20.0±0.7	5.40±0.09	1.68±0.07
Lapeer Co., Flint River.	≈3.0[b]	⩽0.2	21.72±1.1	8.7±0.1	18.1±0.3	5.60±0.10	1.37±0.04
Roscommon Co., Canoe Camp Rd.	3.73±0.03	0.19±0.003	23.28±0.1	9.6±0.1	19.7±0.4	6.35±0.06	1.82±0.10
Crawford Co., Hartwick Pines.	≈3.0[b]	⩽0.2	26.90±0.1	8.4±0.1	19.5±0.10	5.97±0.10	1.15±0.09

[a] Anther length (AL), lemma vestiture (LV), leaf margin vestiture (LM), palea length (PL), awn length (AWN L), rachilla extension (RE), upper glume length (UG).

[b] Data from pre-anthesis plants.

populations from Michigan. PL values were obtained from mid-inflorescence spikelets. LM was measured as previously described. The results, shown in Figure 1, indicate complete correlation between LM and LV, and show that both are strongly correlated with PL.

Of the 11 populations analysed in this study, the Goose Lake (Kalamazoo Co.) population uniquely possessed character combinations which suggested intergradation between varieties. The measurements of AL, LV, and LM condition indicate a similarity of this population to var. *erectum* (Table 2), although anther length was significantly less than in all but the Warren Woods population. On the other hand, palea length and general growth form of the Goose Lake plants suggested var. *septentrionale.* A similar combination of

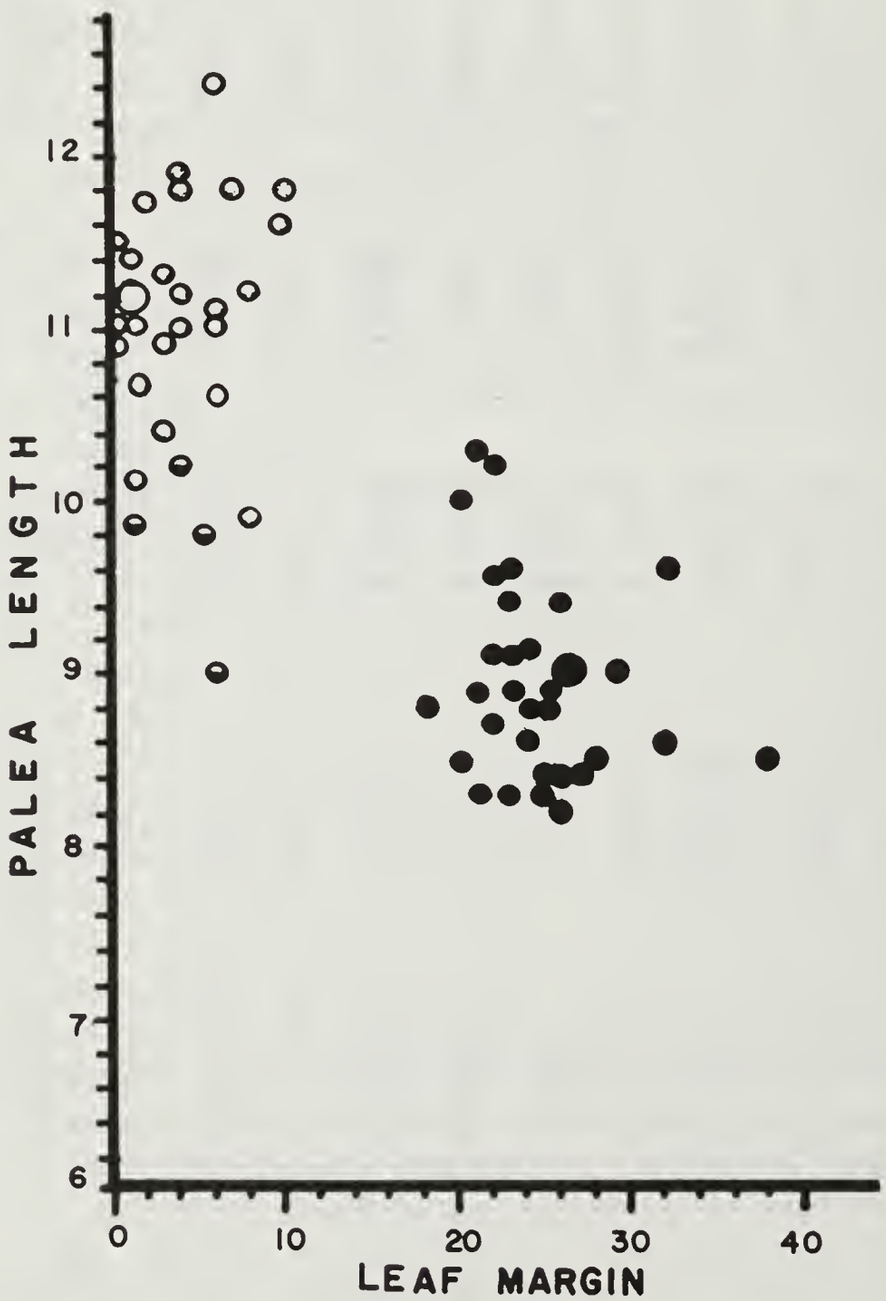

Fig. 1. Scatter diagram showing relationship between palea length, leaf margin vestiture, and condition of lemma vestiture. Solid circles indicate lemma pubescence $\leqslant$0.2 mm; open circles indicate lemma pubescence $\geqslant$0.5 mm; half circles show position of suspected intergrade plants which, in all cases, possessed lemma pubescence $\geqslant$0.5 mm. (The larger circles represent five or more observations.)

characters was noted in herbarium specimens from several other southern localities. While all of these specimens possessed the long spikelet pubescence character, the density of pubescence tended to be less on the main nerves of the lemma than in var. *erectum* and there were few or no internerve hairs.

An additional indication of the intermediate nature of these southern populations is shown in the results (Table 3) of the cumulative probability test, which is fully explained by Davidson and Dunn (1966), using only those characters for which values of the two taxa overlap. Included in this analysis were data for length and width of third sub-terminal leaves. Data from Warren Woods (Berrien Co.) and Canoe Camp Road (Roscommon Co.) populations were utilized for reference distributions of vars. *erectum* and *septentrionale* respectively.

Leaf dimension data are as follows: leaf width, var. *erectum*, $\bar{X} = 1.34$, (cm), $\sigma = 0.29$, var. *septentrionale*, $\bar{X} = 1.20$, $\sigma = 0.19$, $t = 12.49$, $P < 0.001$; leaf length, var. *erectum*, $X = 13.7$, $\sigma = 1.1$, var. *septentrionale*, $\bar{X} = 12.1$, $\sigma = 1.65$,

TABLE 3. Relationship between spikelet vestiture (SV), leaf margin vestiture (LM), and Cumulative Probability (CP) values (based on characters with overlapping values) for selected populations. CP_e = *erectum*; CP_s = *septentrionale*, d = difference between CP values. Superscript indicates variety to which population sample belongs; e = *erectum*, s = *septentrionale*, i = intermediate.

Locality	SV	LM	CP_e	CP_s	d
Keweenaw County	⩽0.2 mm	21	.29	.70	$.41^s$
Crawford County	⩽0.2 mm	20	.12	.55	$.43^s$
Ogemaw County	⩽0.2 mm	28	.14	.61	$.47^s$
Roscommon County	⩽0.2 mm*	23	.14	.75	$.61^s$
Lapeer County	⩽0.2 mm	26	.26	.55	$.29^s$
Clinton County	⩽0.2 mm	22	.42	.79	$.37^s$
	⩾0.5 mm	4	.57	.07	$.50^e$
Kent County	⩾0.5 mm	4	.70	.22	$.48^e$
Ottawa County	⩾0.5 mm	4	.64	.09	$.55^e$
Ingham County	⩽0.2 mm	22	.04	.53	$.39^s$
	⩾0.5 mm	3	.64	.20	$.34^e$
Calhoun County	⩾0.5 mm	2	.67	.18	$.49^e$
Barry County	⩾0.5 mm	1	.71	.37	$.34^e$
Kalamazoo County	⩽0.2 mm**	30	.32	.76	$.44^s$
	⩾0.5 mm***	8	.59	.55	$.04^i$
Cass County	⩾0.5 mm	3	.53	.44	$.09^i$
St Joseph County	⩾0.5 mm	2	.61	.51	$.10^i$
Berrien County	⩾0.5 mm*	0	.72	.14	$.58^e$
	⩾0.5 mm	2	.25	.38	$.13^i$

*Specimens drawn from same populations as reference distribution.
**Specimens from Conrad Bog site.
***Specimens from Goose Lake site.

$t = 5.81$, $P < 0.01$. Other data used in this analysis are included in Table 2.

The cumulative probability values [CP] were calculated for each population sampled using the formula

$$CP = 1 - \prod_{i=1}^{r} (1-p_i) \qquad \text{where}$$

p is the probability associated with measurement intervals in each reference distribution. Thus, two CP values are calculated for each population sample; these CP values provide an estimate of the similarity between individual populations and the reference distributions representing vars. *erectum* and *septentrionale.* The results of this analysis further point out the strong correlation between the non-overlapping characters, i.e., SV, LM, and insofar as could be determined, AL, and the characters with overlapping ranges.

FIELD AND GREENHOUSE STUDIES

The field transplant studies were generally inconclusive. Plants from all localities survived through the initial growing season (1968), but remained vegetative. During the 1969 growing season all var. *septentrionale* transplants died, whereas a few of the var. *erectum* ramets survived although they remained vegetative. In any event, transplant techniques and/or site conditions were apparently unfavorable for vigorous establishment of either taxon. The results do suggest, however, that some feature of the maple-beech forest environment is less favorable for var. *septentrionale* than the var. *erectum,* even though some ramets of the former were transplanted from a similar upland forest site (Newman Road, Ingham Co.).

In contrast to the field transplants, greenhouse-grown plants were vigorous and survival was 100 percent. No differences in phenetic characters were found between these and the corresponding *in situ* ramets or herbarium specimens from them. There was, however, a greater proportion of non-reproductive tillers produced in the greenhouse plants than in the field.

Figure 2 shows the growth rate and developmental pattern of the greenhouse plants. The Roscommon Co. (var. *septentrionale*) plants responded more quickly to the greenhouse conditions than did the Ingham Co. (var. *erectum*) plants, producing at least one leaf prior to significant initial activity in the southern plants. Since the northern populations had been exposed to a longer and more extreme natural cold treatment prior to collection than were the southern populations (both northern and southern materials were collected December 20, 1967), a second set of materials was obtained March 20, 1968. The second set of materials was handled in an identical manner and, except for somewhat longer daylengths, was grown under the same conditions. The results of the second run suggest that the previously observed differences in initial growth response resulted either from differing natural cold treatments or differing daylength response. More significant, however, were the conspicuous differences in the rate of development of the two taxa, i.e., the more rapid growth and earlier maturity of var. *septentrionale.* The fact that this pattern of development was essentially the same in both runs suggests that it

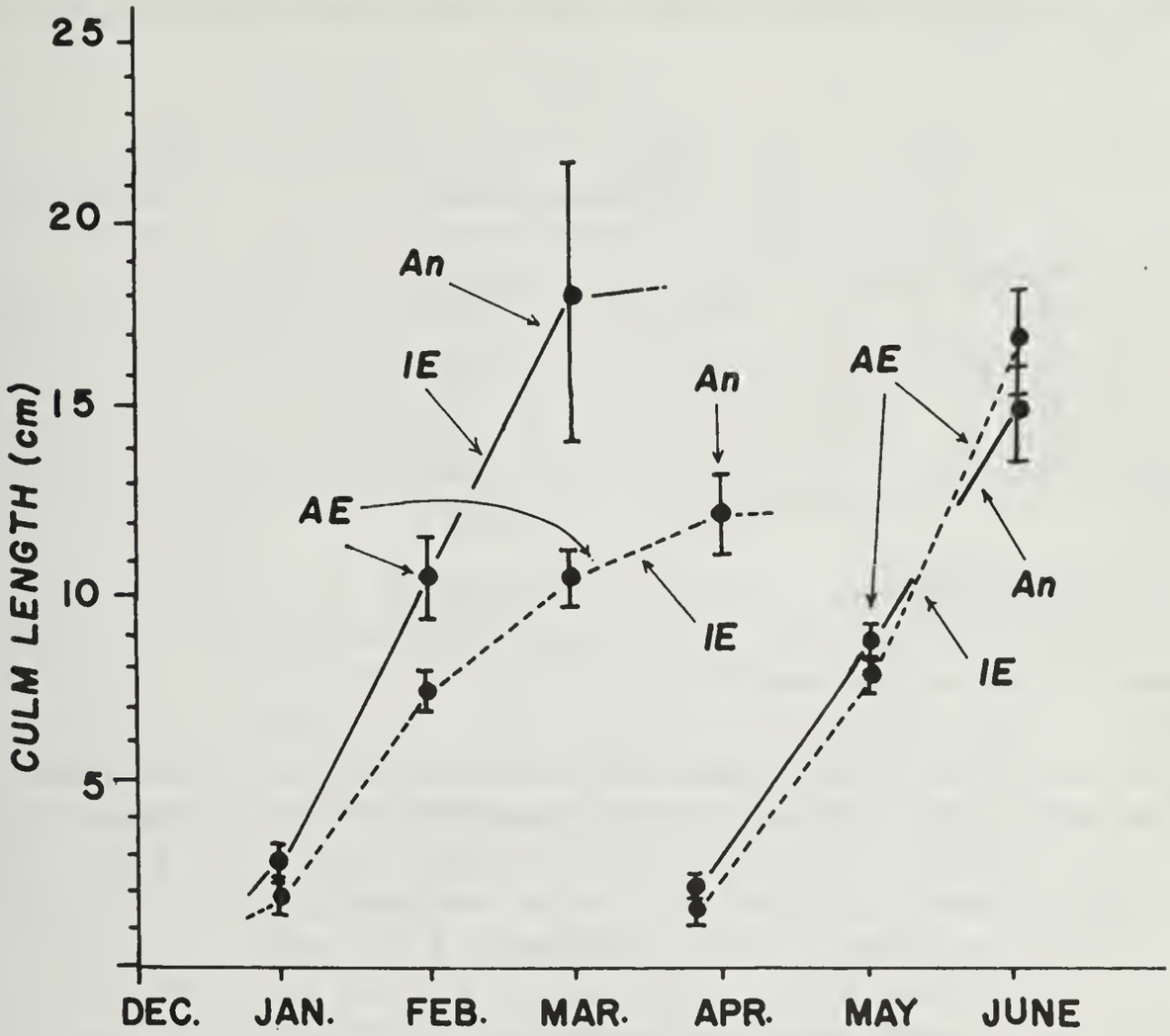

Fig. 2. Growth and development of greenhouse-grown *Brachyelytrum.* Culm lengths were measured from soil surface to the base of the uppermost leaf. Points are means of four replicates; vertical bars represent 95% confidence intervals. AE = awns exserted; An = anthesis; IE = inflorescence exserted. The broken line indicates var. *erectum*; the solid line indicates var. *septentrionale.*

is a genetically controlled character and constitutes a fundamental difference between the two taxa.

Observations in the field during the 1968 and 1969 growing seasons also demonstrated marked differences in the phenology of the two taxa (Table 4). In the several Ingham Co. localities observed, (Baker Woodlot and Bear Lake Woods–both MSU campus, and Newman Road), all *Brachyelytrum* populations commenced growth at the same time; however, by early June var. *septentrionale* was obviously developing more rapidly than var. *erectum.* The initial appearance of awns, marking the beginning of inflorescence exsertion, occurred 2 to 4 days sooner and anthesis occurred 8 to 10 days sooner in var. *septentrionale* than in var. *erectum.* It would appear that this was not a local phenomenon since anthesis in the Roscommon Co. var. *septentrionale* populations preceded, by at least 5 days in 1968, that in Berrien Co. var. *erectum* populations over 200 miles to the south. It was also observed that anthesis in the field was highly synchronous throughout a given population. In the Newman Road populations anthesis was completed, insofar as could be

TABLE 4. Phenology records for *Brachyelytrum* at the Newman Road (Ingham Co.) site for 1968 and 1969.

Developmental stage	Date recorded			
	1968	1969	1968	1969
	var. *septentrionale*		var. *erectum*	
First true leaf; culms ca. 4 cm in height.	Apr. 10	Apr. 16	Apr. 10	Apr. 16
Three leaves; culms ca. 15-25 cm in height.	May 16	May 20	May 16	May 20
Five to 7 leaves; inflorescence exserted.	June 19	June 17	June 22	June 20
Anthesis	July 3	July 7	July 11	July 19*
Spikelets turning brown; inflorescence nodding.	July 20	July 25	Aug. 10	Aug. 10

*Estimated from condition of anthers.

determined, within a single day. The majority of the var. *septentrionale* population had completed blooming by mid-morning of the day anthesis occurred. Anthesis, however, was not synchronous between populations within a region; e.g., the Newman Road populations of var. *erectum* bloomed one day prior to that of the same taxon in Baker Woodlot and 3 days prior to that of the same taxon in Bear Lake Woods. Consequently it would appear that severe constraints are imposed upon inter-population gene flow, even between populations of the same taxon.

ECOLOGIC AND GEOGRAPHIC DISTRIBUTION

Due to extensive and varied disturbance of natural habitats it is impossible to construct a complete picture of the former distribution of *Brachyelytrum* in Michigan. However, observations made during the course of this study have been instructive in understanding the ecology of both varieties, and have contributed indirectly to reconstruction of their probable former distribution.

Throughout its range in Michigan, var. *erectum* was found chiefly in old or mature, mesic hardwood forest remnants, with an understory vegetation indicative of relatively little recent disturbance. The predilection of this taxon for well developed, mesic hardwood forest communities is shown by Parmelee (1953), who found *Brachyelytrum* (unspecified as to variety) only in the mesic half of the southern Michigan oak forest continuum. A check of the herbarium specimens[3] from these stands revealed that, with the exception of one Clinton Co. site where both taxa occurred, the plants were var. *erectum.* Typical sites in which var. *erectum* occurs support a rich vernal flora including the following genera: *Erythronium, Claytonia, Trillium, Viola, Erigenia, Osmorhiza, Podophyllum, Dentaria, Dicentra,* and *Sanguinaria.* Common grass associates are *Muhlenbergia tenuiflora* (Willd.) BSP., *Oryzopsis racemosa* (J. E.

[3]Specimens in the Beal-Darlington Herbarium at Michigan State University.

Smith) Ricker, *Milium effusum* L., *Hystrix patula* Moench, and several species of *Poa.*

The Otis Lake (Barry Co.) site differed from other localities where var. *erectum* was well established in that the understory flora was a mixture of species common to mesic hardwood communities and some species more characteristic of oak-hickory forests, e.g., *Carex pensylvanica* Lam., *Panicum latifolium* L., and *Gaultheria procumbens* L. The Goose Lake site represents what appeared to be the driest of the upland sites in which *Brachyelytrum* was found in southern Michigan. Here *Carex pensylvanica, Gaylussacia baccata* (Wang.) K. Koch, and *Vaccinium* sp. were the most abundant understory plants, although the adjacent lake margin community, where a few *Brachyelytrum* plants were found, was considerably more diverse and indicative of less acid soil conditions.

Unlike var. *erectum,* the distribution of var. *septentrionale* in southern Michigan is local and generally associated with poorly drained, markedly acid soil conditions. At the Conrad Bog site the understory plants with which *Brachyelytrum* was associated consisted mostly of *Carex* spp., *Glyceria striata* (Lam.) Hitchc., *Panicum boreale* Nash, *Trientalis borealis* Raf., *Vaccinium* sp., *Gaultheria procumbens, Maianthemum canadense* Desf., and *Melampyrum lineare.*

Pohl (1947) cited a similar disjunct occurrence of var. *septentrionale* well south of its range in Pennsylvania where it is associated with plants of northern affinities.

Where vars. *erectum* and *septentrionale* are found together in the same locality, e.g., the Newman Road site (Ingham Co.), there is some tendency, albeit poorly defined, toward segregation on drainage gradients, with var. *septentrionale* at the poorly drained end. This locality consists of approximately 160 acres of mixed woodland through which runs a chain of small bogs and lowland depressions. The vegetation of these lowland sites ranges from *Cassandra-Larix*-dominated to *Ilex-Vaccinium-Pyrus*-dominated. While both varieties were found in the upland portion of the site, only var. *septentrionale* occurred along the margin of the lowlands. However, samples within individual populations of the two taxa (17 var. *erectum,* 13 var. *septentrionale*) failed to demonstrate significant differences in either the quantity or the composition of the cover contributed by understory plants associated with either taxon.

The second site I examined where the two taxa were found growing close together was near Maple Rapids (Clinton Co.). This site is an old second-growth red oak dominated woodlot (Stand 27, Parmelee 1953) with several large moist depressions near the center. Neither of the taxa were abundant in the woodlot, but var. *erectum* was found only in the well drained uplands, whereas var. *septentrionale* was found only along the margins of the lowland area.

With increasing latitude var. *septentrionale* becomes less habitat-specific and in the Upper Peninsula it becomes a common component of the uplands, as do many of the species with which it is associated farther south. For

example, in Iron Co. it was frequently observed in the open "stump fields," all that now remains of once dense pine stands, growing within and between clumps of *Corylus* and other shrubs. It was also commonly observed in deep shade conditions within copses of *Picea* and *Abies* in the uplands, and *Picea* and *Thuja* in and around bogs.

It should be noted that much of the present vegetation over the continuous range of var. *septentrionale* in Michigan is the result of extensive disturbance, e.g., the Iron Co. area previously mentioned. It might therefore be inferred that this taxon is tolerant of or even benefits from disturbance within the range of edaphic and biotic conditions to which it is adapted. On the other hand var. *erectum* appears to be eliminated by any but small-scale disturbances, such as windthrow gaps, which are a normal and predictable part of forest development and maintenance.

The geographic distribution of both taxa (Figure 3) is apparently, at present, a reflection of their limitation to specific habitats. Although conspicuous lacunae are apparent in the distribution map this is probably an artifact of past collecting activity more than anything else. It is likely that with a more extensive search the occurrence of var. *septentrionale* could be

Fig. 3. County distribution of *Brachyelytrum erectum* in Michigan. Solid circles represent var. *septentrionale;* open circles represent var. *erectum;* half circles represent suspected intermediates.

demonstrated for all central and northern counties, and perhaps all southern counties as well. However, the search of the latter during the course of this study was intensive enough to indicate that var. *septentrionale* is relatively rare in the southwestern portion of the state. Likewise, it is assumed that the absence of var. *erectum* in seemingly appropriate mesic hardwood stands north of its presently known limits reflects its pre-settlement distribution, and is not the result of man's recent activity. Fassett (1951) shows a similar abrupt northern limit for var. *erectum* in Wisconsin. Consequently it would appear that the overall distribution pattern of the two taxa has not been substantially altered in recent time; rather, the pattern reflects the effects of "natural" controls.

Accepting this proposition then, the central feature of the distribution of both vars. *septentrionale* and *erectum* in Michigan is the obvious relationship between their limits of continuous distribution and the tension zone which obliquely transects the Lower Peninsula. This zone and its relationship to biotic, edaphic, and climatic features in the Great Lakes region has been well documented by Veatch (1932), Potzger (1948), Braun (1950), Curtis (1959), and others. The increasingly discontinuous southward distribution of var. *septentrionale* is characteristic of species which were once more widely distributed in the region, but are now restricted to relictual habitats as the result of stress from climatic, geomorphic, or biotic changes (Cain, 1944). In Michigan this type of distribution is perhaps most conspicuous in bog or bog-associated species. For these species the tension zone marks a region south of which they become localized in occurrence.

In contrast to the distribution of var. *septentrionale,* the essentially continuous distribution of var. *erectum* south of the tension zone, with few or no outlying northern populations, suggests that this zone acts as a barrier to the northward expansion of the taxon. There is no obvious explanation for its observed absence from seemingly appropriate habitats northward (as far as Grand Traverse Bay). However, many of these sites include varying amounts of *Tsuga* and occasional *Pinus,* and a distinct boreal element in the understory, and may therefore represent a transitional stage of development in which var. *erectum* is unable to become established. The absence of var. *septentrionale* from these stands is also curious since both taxa are found together in similar sites further south.

The distribution pattern of *Brachyelytrum* in Michigan is similar in many respects to those shown for *Claytonia* (Voss, 1968) and *Toxicodendron* (Gillis, 1962; 1969). In the case of *Claytonia,* however, the southern species, *C. virginica,* occurs farther north than *B. erectum* var. *erectum*; and the northern species, *C. carolinina,* unlike *B. erectum* var. *septentrionale,* apparently does not occur as disjunct populations southward. Like *Brachyelytrum,* the two Claytonias occasionally occur together; however, the zone of overlap is located farther north in Michigan than is the case for *Brachyelytrum.*

Toxicodendron shows a somewhat different distribution pattern. Whereas the more southern species, *T. radicans,* is found further north than *B. erectum* var. *erectum,* the area shapes of both taxa are much the same. On the

other hand, *T. rydbergii,* the northern poison-ivy, ranges southward more or less continuously along the shore of Lake Michigan but is absent southward on the eastern side of the state. This pattern is just the opposite of that observed for *B. erectum* var. *septentrionale.*

Doubtless many other taxa in the state, if examined in detail, would show similar north-south relationships, each with variations in its distribution pattern and each showing a unique relationship to the tension zone.

IN CONCLUSION

In view of the differences in distribution, ecology, and apparent reproductive isolation, the relationship between the taxa presently recognized as vars. *erectum* and *septentrionale* appears to be one of differentiation at the species level, at least in the Great Lakes segments of their ranges. The differences in phenology suggest that at least the Great Lakes segments or topodemes (*sensu* Briggs & Walters, 1969) of the two taxa developed under differing conditions as components of two differing vegetation types. This differentiation may have occurred elsewhere precedent to their post-Pleistocene entry into their present range in Michigan. However, the evidence from distribution data is too scanty at this time to allow any conclusion as to whether the two taxa arrived here via different migration routes.

The recognition of these taxa as species (or at least as entities with differing evolutionary histories) is of fundamental interest to the ecologist who uses species as indicators of community relationships or in studies of community structure and development. Further investigation of *Brachyelytrum* over the entirety of its range is needed to establish the constancy of the differences which characterize vars. *erectum* and *septentrionale* in Michigan.

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Voss, E. G. 1968. The spring beauties (Claytonia) in Michigan. Mich. Bot. 7: 77-93.

Back Issues Needed

Our supply of complete sets of back issues is dwindling and there is still a demand for them from new institutional (and other) subscribers. The two numbers of Vol. 1 (1962) are especially short. The following numbers would be particularly welcome if subscribers have copies for which they have no further use; send them to the business and circulation manager (postage will be refunded):

Vol. 1, No. 1 & No. 2	Vol. 5, No. 1
Vol. 2, No. 1	Vol. 5, No. 3 & 3A
Vol. 4, No. 3	Vol. 9, No. 3

The above numbers are no longer available for sale as single copies, as the entire stock is reserved to make up complete sets.

VARIABILITY IN BARK MORPHOLOGY OF YELLOW BIRCH IN AN EVEN-AGED STAND

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During a study of natural variation of yellow birch (*Betula alleghaniensis* Britton) in Michigan, we have observed a wide range of variability in bark exfoliation of trees 5 to 15 in. in diameter at breast height (DBH). For example, in various natural populations, we have noticed trees with smooth bark growing alongside similar-sized trees with exfoliating bark.

It has been shown that some of the variation in bark characteristics of many tree species is related to the vigor and age of the trees (Burkle & Guttenberg, 1952). Clausen and Godman (1969) found that yellow birches with smooth or peeling bark tend to be younger than "rough-barked" birches of similar diameter. The rough-barked trees averaged nearly twice as old (135 vs. 75 years) and in one instance were almost 4 times as old (206 vs. 56 years) as similar-sized trees with smooth or peeling bark. According to Clausen and Godman, "rough bark appears to be less common than the smooth type and may not occur in all stands." We believe these rough-barked trees are overmature or very slow-growing individuals. Excluding the rough bark types, we have observed a continuum of smooth to exfoliating types in most stands.

We assume the variability in a given stand is due both to genetic differences between individuals and such factors as age, size, vigor, and microenvironment of the trees. However, if a close relationship exists between a given bark type and size or age of the trees, the genetic component would be greatly masked. Specifically: Are smooth-barked trees younger than their highly exfoliating associates? Are the exfoliating trees typically larger than the trees with smooth bark? If there is no significant relationship of bark morphology to age and size, the phenotypic differences observed would indicate more clearly the variety of genetic differences between the trees. Thus, the objective of this study was to determine the relationship of smooth and exfoliating bark types to diameter (as a measure of vigor) within an essentially even-aged stand.

STUDY SITE AND METHODS

A stand of yellow birches was selected in the NE ¼ of the NE ¼, Sec. 8, T 44 N, R 36 W, Iron County, Michigan. It was chosen because there were many individuals of different diameters present in the stand. Also, the site conditions were relatively uniform. Twenty-five yellow birches were chosen to represent the range of bark types and diameters present in the population. Two photographs were taken on opposite sides of each tree (generally north and south) at about 4 to 5 ft. above the ground. DBH was measured with a

diameter tape, and increment cores taken at 4½ ft. above the ground. The ages of the trees were later determined from these cores.

Three bark characters were scored from the photographs. Regressions of each of the 3 characters were made against age and diameter. The 3 characters were 1) *bark smoothness:* rated on the scale (a) bark essentially smooth, (b) bark with some exfoliation, and (c) bark with abundant exfoliation; 2) *ranked bark smoothness:* trees ranked in order from 1 (smoothest bark) to 25 (most exfoliating bark); and 3) *thickness of exfoliation:* (a) fine or thin exfoliation and (b) coarse or thick exfoliation.

RESULTS AND DISCUSSION

Increment cores from the 25 trees showed a range in age from 58 to 63 years, and averaged 60.1 years at 4½ ft. above the ground. This indicates that the stand is even-aged and that the trees probably developed from seeds that germinated in one year. The trees ranged in size from 5.3 to 11.3 in. DBH, and averaged 8.2 in. There was no significant relationship between diameter and the minor differences in age ($P > .25$).

There was a marked variability in bark characteristics of the yellow birches in the population (Fig. 1) similar to the variability found in a population in southeastern Michigan (Dancik, 1969). However, there was no significant relationship between age and diameter and 1) bark smoothness ($p > .25$), 2) ranked bark smoothness ($p > .25$; see fig. 2), and 3) thickness of the exfoliation ($p > .10$). Thus we conclude that the variation is not due to age or size differences but to genetic differences between the trees and modification of the genotypes by local environmental conditions. Since the site seems to be rather uniform over the small sample area and the bark types are randomly distributed over the site, most of the phenotypic variation can probably be attributed to genetic differences between the trees.

Nevertheless, we perceive differences in bark morphology due to age, size, and vigor; sometimes a progressive change may occur in bark morphology over the life span of the tree. Very young birches (2-3 in. DBH or less) typically have smooth bark with little exfoliation. Exfoliation increases with increasing age and size for some individuals. Others retain their smooth bark as they increase in size. Larger trees, up to possibly 70-100 years of age, exhibit a wide range of bark forms from smooth to very exfoliating. That such a range can occur on a given site was shown in this study. Very old or very slow growing trees are more likely to have a rough, furrowed, sometimes even plated bark, as demonstrated by Clausen and Godman. Although our data were taken from only one stand, they suggest that the smooth and peeling bark types are not closely related to age and vigor per se. Further studies on a variety of sites would be necessary to give more substance to these hypotheses.

It is interesting to note that while many of the individuals in the population had a smooth and dark bark, none approached the very dark and smooth bark that was common in a population we studied in southeastern Michigan (Dancik, 1969; Dancik and Barnes, in press). The northern Michigan

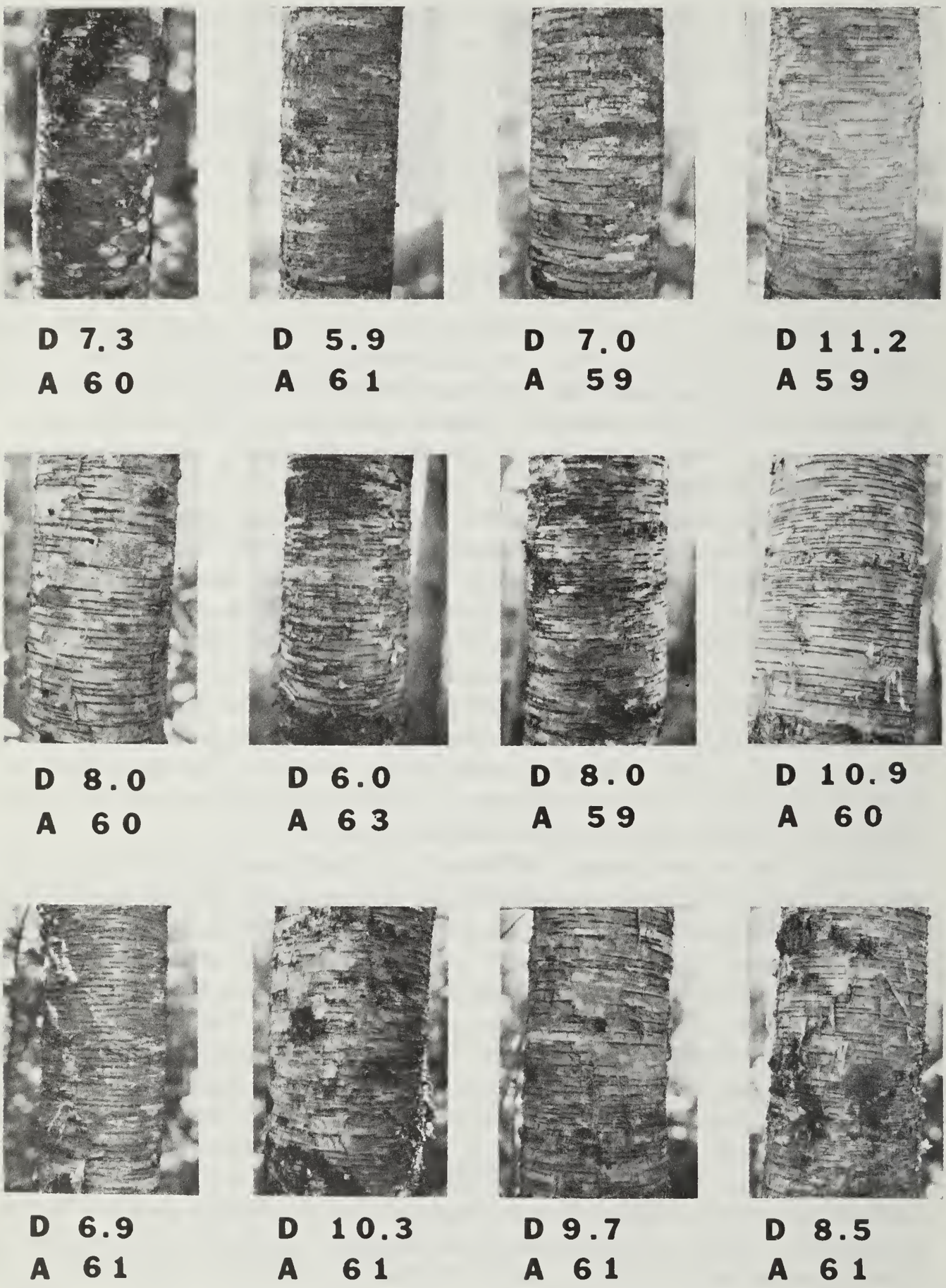

Fig. 1. Stem photographs of 24 of the 25 yellow birches sampled. They are arranged in order from the tree with the smoothest bark (upper left) to the tree with the most bark

D 5.8
A 59

D 9.1
A 60

D 11.3
A 61

D 5.9
A 58

D 8.2
A 59

D 6.3
A 58

D 9.7
A 61

D 9.2
A 60

D 6.5
A 58

D 5.3
A 61

D 8.2
A 59

D 10.5
A 61

exfoliation (lower right). D = diameter at 4½ ft. in inches; A = age of tree in years (at 4½ ft.).

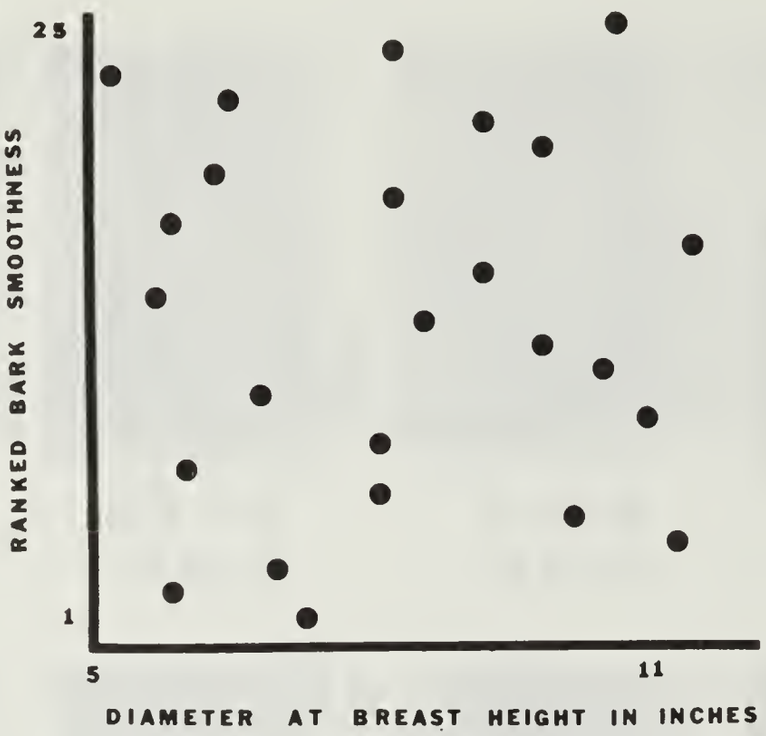

Fig. 2. Relationship of ranked bark smoothness (1 = tree with the smoothest bark, 25 = tree with the greatest degree of exfoliation) to tree diameter.

population also had a lower proportion of smooth-barked forms and a correspondingly greater proportion of light-barked, highly exfoliating forms than the southeastern Michigan population.

ACKNOWLEDGMENTS

Support of investigations of the birches by funds provided under the McIntire-Stennis Law (P. L. 87-788) is gratefully acknowledged.

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Clausen, Knud E., & Richard M. Godman. 1969. Bark Characteristics Indicate Age and Growth Rate of Yellow Birch. U.S.D.A. Forest Serv. Research Note NC-75. 4 pp.

Dancik, Bruce P. 1969. Dark-barked birches of southern Michigan. Mich. Bot. 8:38-41.

Dancik, Bruce P., & Burton V. Barnes. In Press. Natural variation and hybridization of yellow birch and bog birch in southeastern Michigan. Silvae Genetica.

ISOTRIA MEDEOLOIDES, THE SMALLER WHORLED POGONIA, IN MICHIGAN

Frederick W. Case, Jr.
Arthur Hill High School, Saginaw, Michigan
with
William Schwab
Elston Senior High School, Michigan City, Indiana

What surely must be one of the most remarkable orchid occurrences in Michigan history has come to light with the discovery of the smaller whorled pogonia, *Isotria medeoloides* (Pursh) Raf., in the southwest part of the state. Because of the extreme rarity of the species, and because of the great interest in it, a brief account of the discovery and of the plant may be of interest.

In early June, 1968, Mr. William Schwab discovered a colony of about a dozen whorled pogonias in a low sandy-acid woods in Berrien County, Michigan. A keen student of nature and one interested in the native orchids, Mr. Schwab had been on the lookout for the whorled pogonia, *Isotria verticillata* (Muhl. ex Willd.) Raf., for some time and was familiar with its characteristics. Since the plants he found did not seem quite right, he made a thorough comparison with the descriptions in Correll (1950) and others. His diagnosis was not that they were the rather widespread native *I. verticillata,* but rather that his specimens were *I. medeoloides.* A check with my book (Case, 1964) made no mention of the smaller whorled pogonia from Michigan, or from any station near Michigan. Thinking himself somehow in error, Mr. Schwab decided to wait another season and recheck his plants. In June of 1969 he wrote to ask me to check and confirm his discovery. I would have been quite skeptical of his identification were it not for the obvious care he had taken with his diagnosis and notation of characters, and were it not that so many southern or primarily Coastal Plain and Piedmont species of plant have been collected in this same general region of Michigan.

A delay in my mail plus other field commitments made it late in the flowering season before I could check the pogonia station, so when I visited the *Isotria* colony, I took along a plant of the typical *I. verticillata* for comparison, in case flowering had ceased. Contrast between the two plants was great. The plant of *I. verticillata* was nearly twice as tall as were the plants in Mr. Schwab's colony. The stem of *I. verticillata* was purplish and graded into green only upward near the whorl of leaves. Those of the new plant were uniformly grey-green, with a whitish bloom throughout. The leaves of *I. medeoloides* were less obovate, smaller, less abruptly tapered apically, drooping not elevated above the point of attachment as are those of *I. verticillata* in anthesis, and were a peculiar, uniform green, not yellowish green as in *I. verticillata,* and with a prominant whitish bloom. In manner of growth yet another difference stood out: *I. verticillata* tends to form small clumps of

several stems arising within a few inches of each other. The new plants were all solitary stems standing completely apart from each other at distances of several yards. Although the flowers had passed, two fairly fresh, detached blooms were found hanging from leaf whorls. In both of these, though wilted, the "key characters" stood out. The flowers lacked a distinct, elongated peduncle, and the sepals were only slightly longer than the petals. The sepals did not spread. In *I. verticillata,* the sepals greatly exceed the petals, often by 3-4 times, and spread widely. (See Figs. 1 & 2.)

Further search revealed a plant with a well developed seed capsule, and here another distinction became apparent. In *I. verticillata* the pedicel, in fruit, is at least twice as long as or longer than the capsule: in *I. medeoloides,* the pedicel is about equal to the capsule. (See Figs. 3 & 4.) The plants differed in so many ways that there could be no doubt, it was *I. medeoloides!*

Because this discovery is so completely out of the known range of the plant, we decided to wait yet another season so as to secure a good herbarium specimen for the scientific record before reporting the species from Michigan.

On May 30, 1970, we visited the colony again. At that time, seven plants were in evidence as compared to twelve the previous season. (The plant is often cited as having dormant periods of up to 20 years during which it persists underground (Wherry, in Correll 1950, p. 145.) While I sincerely doubt such a growth pattern to be a common occurrence, several plants marked the previous season were not in evidence.)

Of the seven plants we found, one was in flower and was typical *I. medeoloides.* The plants grew in a flat, sandy, damp grove dominated by red maple (*Acer rubrum*), a black oak or two, black gum (*Nyssa sylvatica*), and few other tree species. According to Mr. Schwab, the area had been planted to

Fig. 1. (left). *Isotria medeoloides,* Berrien Co., Michigan, May 30, 1970.
Fig. 2. (right). *Isotria verticillata,* Calhoun Co., Michigan, June, 1962.

an orchard years ago and finally allowed to go back to woodland. At the point where the orchid grew, the two or three overhead trees were quite large, while most others nearby are small, with trunk diameters of 6-8 inches. Little herbaceous undergrowth appears except for some weak plants of *Maianthemum canadense.* Dead, matted leaves of red maples cover the ground. A few yards away grow a few royal and marsh ferns (*Osmunda regalis* and *Dryopteris thelypteris*). In nearby clearings grow meadowsweet (*Spiraea alba*), *Habenaria lacera, Spiranthes cernua,* and wild strawberry (*Fragaria* sp.). Nothing about the station seemed significantly different from a thousand similar spots in the area.

Isotria medeoloides is apparently rare everywhere. Correll (1950) gives its range as "Found locally in New England, New York, Pennsylvania and New Jersey (Bergen County), south to Virginia (James City County) and North Carolina (Cumberland (?) and Surry counties); also Missouri (Bollinger County)."

Harvill (1969) reports the discovery of a single plant of *I. medeoloides* from the Piedmont of Virginia. In 1968, H. S. Veltman, my family, and I attempted to rediscover the Surry County, North Carolina, station near Mt. Airy. Although we had the directions to the plants as described by the discoverer of the station, and although the directions fit exactly the field situation, we failed to locate the plant.

My personal contacts with a rather large segment of American wild orchid photographers and interested naturalists suggests that only about three colonies of this orchid remain well-known either to scientists or laymen. Two

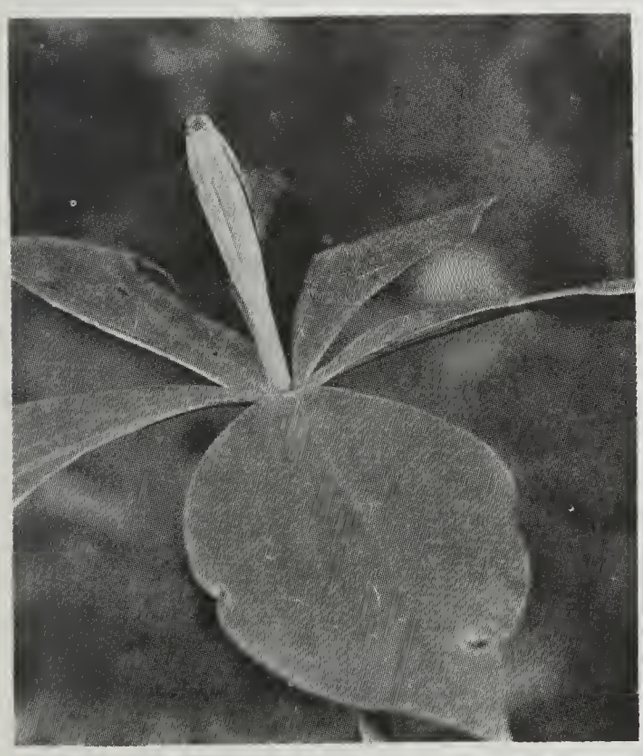

Fig. 3. (left). *Isotria medeoloides,* Berrien Co., Michigan, June 28, 1969. Note short peduncle in relation to capsule length.
Fig. 4. (right). *Isotria verticillata,* Saginaw Co., Michigan, August, 1969. Note long peduncle.

of these colonies are in New Jersey, one in Virginia. Most observations and photographs of this species taken in the past 40 years seem to have been made at the Virginia station, which was first described by Morris and Eames (1926). Correspondents inform me that real estate development now threatens to destroy the colony.

The only previous substantiated record of which we are aware for the smaller whorled pogonia west of the Appalachian Mountains is the Bollinger County, Missouri, record cited by Correll. Since so few colonies are known anywhere, the Michigan record seems particularly remarkable.

Of course, it may be that *I. medeoloides* is actually of more frequent occurrence than has been believed. *I. verticillata* and *I. medeoloides* can occur together in the same woods (Morris & Eames, p. 232). In neither species do many plants flower in any given season. Blossoms are often ephemeral, especially on *I. medeoloides.* Mr. Schwab reports that the plants in his colony have dropped flowers after just a day or two. With such a situation, a few scattered plants of *I. medeoloides* (which does not form clumps) could easily go undetected among numerous plants of the commoner large whorled pogonia.

In Michigan, reports of upland colonies of *any* whorled pogonia are very unusual. Excepting three of my own stations, almost every herbarium specimen I have examined came from sphagnum bogs. Indeed, I have found many more bog than upland stations myself. *I. medeoloides* is not a bog plant. We would, therefore, alert naturalists and botanists to the presence of the smaller whorled pogonia in Michigan, and suggest that anyone who discovers *Isotria* plants in an upland situation check identification of the plants carefully for the possibility of *I. medeoloides.*

The Michigan colony of small whorled pogonia grows in an area being slowly developed for real estate speculation, and the colony of this very rare plant is in real danger. We will, therefore, make an effort through an appropriate scientifically oriented conservation organization to acquire and preserve this remarkable orchid station.

Since the publication of my book (Case, 1964) I have learned that the announcement of a station for any rare orchid species will inevitably cause many eager, dedicated, and capable photographers and naturalists to seek us out, each swearing secrecy, dedication to conservation principles, and only the desire to see or photograph this plant. Nearly all are honest about this. But photographers will show their slides, and others will ask, and soon people come from near and far. With so rare a plant such attention could in many ways destroy the station. The authors agree that an adequate scientific record is necessary. Therefore, we have taken one specimen and deposited it in the University of Michigan Herbarium. We will now work to have the small woodlot preserved. But we feel it would be wrong to act as guides to everyone who desires to see this rare plant, and in so doing possibly contribute to the destruction of the only known colony in the Great Lakes region of one of America's rarest orchids.

LITERATURE CITED

Case, F. W., Jr. 1964. Orchids of the Western Great Lakes Region. Cranbrook Inst. Sci. Bull. 48. 147 pp.

Correll, D. S. 1950. Native Orchids of North America North of Mexico. Chronica Botanica, Waltham. 399 pp.

Harvill, A. M., Jr. 1969. Isotria medeoloides on the Piedmont of Virginia. Rhodora 71: 303-304.

Morris, F., & E. A. Eames. 1929. Our Wild Orchids. Scribner's, New York. 464 pp.

Publications of Interest

MANUAL OF THE CARICES OF THE ROCKY MOUNTAINS AND COLORADO BASIN. By Frederick J. Hermann. Forest Service, U. S. Department of Agriculture Handbook 374. 1970. 397 pp. $3.50 (buckram). In this manual, 164 species are fully keyed and described and illustrated by full-page drawings, the latter mostly by Charles Feddema. This major work by the leading authority on our largest genus of vascular plants will be useful to local botanists desiring a complete description and illustration for species to which they may have keyed their material, for about a third of the species included also occur in the Great Lakes region.

PLANTS IN OUR LIVES. By Kenneth L. Jones. George Wahr Publishing Co., Ann Arbor, 1970. 363 pp. $4.75. Another volume of delightful essays, companion to the author's first one, *Botanical Essays for Humanists,* commended to all Botanical Club members in an earlier issue (5: 119. May 1966). This time we learn about cells, drugs from plants, rice, orchids, succulents (especially heavily watered ones), adaptation, the beauty (including color, fragrance, and feel) of plants, and something about plants in our lives and dooryards—all related with a deep appreciation for plants and with a gentle touch of humor which together make knowledge of important principles almost too painless to acquire! Botanical alumni of The University of Michigan will especially appreciate the words of tribute about such worthies as Volney M. Spalding, E. U. Clover, H. H. Bartlett, and F. G. Gustafson—as well as the airy little drawings again provided by Mrs. Jones.

NOTE: Readers associated with institutions whose libraries have a copy of the book-form reprint of the Index to American Botanical Literature, 1886-1966 (G. K. Hall & Co.), may want to annotate their copies to call attention to the omission of the titles included in the Bulletin of the Torrey Botanical Club for September 1943 (Vol. 70, pp. 550-558). Evidently the set of the Torrey Index from which the reprint was made was not complete.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan Botany under four categories: A. Maps, Soils, Geography, Geology (new maps and selected bulletins or articles on soils and geology as these may be of use to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan;—not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

The following topographic maps for Michigan have been published by the U. S. Geological Survey, 1200 S. Eads St., Arlington, Virginia 22202, since the previous listing in our May 1970 issue. All are 7½-minute quadrangles (scale of 1:24,000 or about 2½ inches to a mile). Maps are supplied with green overprint showing wooded areas unless request is made to the contrary, and are $.50 each, with a 20% discount on orders totalling $20.00 or more. Revised maps are marked with an asterisk in the list below; others are new. Following the name of the quadrangle, the county or counties in which it primarily lies are added.

Almont* [Lapeer]
Belleville* [Wayne]
Bridgeport [Saginaw]
Grand Marais [Alger]
Grand Marais NE [Luce]
Grand Marais SE [Luce]
Lake Orion* [Oakland]
Macon [Lenawee, Washtenaw]
Milan [Monroe, Washtenaw]
Nawakwa Lake [Alger]
Saline [Washtenaw]
Stony Point* [Monroe]
Thornville* [Lapeer]
Wyandotte* [Wayne]
Ypsilanti E* [Washtenaw, Wayne]

Folsom, Michael M., & Harold A. Winters. 1970. Drainage orders in Michigan. Mich. Academ. 2(3): 79-91. [Study of Lower Peninsula drainage systems only, including map, but fails to define "drainage order" or "stream order."]

Gannon, John E., & David C. Brubaker. 1969. Sub-surface circulation in South Fishtail Bay, Douglas Lake, Cheboygan County, Michigan, Mich. Academ. 2(2): 19-35. [Current patterns in relation to wind and temperature.]

Hughes, John D., John P. Farrell, & Edward C. Monahan. 1970. Drift-bottle study of the surface currents of Lake Superior. Mich. Academ. 2(4): 25-31.

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

(Anonymous. n.d.) [1970] Water Weed Control. Michigan Department of Natural Resources. 7 pp. [Folder illustrating 7 major waterweeds, with suggestions on control and statement of regulations governing chemical methods in this area.]

Corner, E. J. H. 1968. A Monograph of Thelephora (Basidiomycetes). Beih. Nova Hedwigia 27. 110 pp. + 6 pl. [*T. scissilis* cited from Isle Royale.]

Crandall, B. J. 1969. Morphology and Development of Branches in the Leafy Hepaticae. Beih. Nova Hedwigia 30. 261 pp. [For several species, the specimens examined (and cited) include Michigan collections, chiefly from near the University of Michigan Biological Station.]

C. JOURNAL ARTICLES

Clémençon, H. 1968. Beiträge zur Kenntnis der Gattungen Lyophyllum und Calocybe (Agaricales, Basidiomycetes) III. Zwei Chlamydosporen bildende Lyophyllum-Arten. Nova Hedwigia 16: 417-427. [Type of new species *L. suburens* from Cheboygan Co.]

Culberson, William Louis. 1969. The chemistry and systematics of some species of the Cladonia cariosa group in North America. Bryologist 72: 377-386. [*C. polycarpoides* mapped and *C. cariosa* cited from Michigan.]

Davis, Roger M., & John E. Cantlon. 1969. Effect of size area open to colonization on species composition in early old-field succession. Bull. Torrey Bot. Club 96: 660-673. [Study in Kalamazoo Co.]

Erbisch, Frederic H. 1970 ["1969"] Development of apothecia, asci, and spores in Melanaria macounii var. meizotoca. Bryologist 72: 489-494. [Material studied was collected in the Porcupine Mountains, Ontonagon Co.]

Fleming, Richard C. 1970. Food plants of some adult sphinx moths (Lepidoptera: Sphingidae). Mich. Entomol. 3: 17-23. [Many plants listed as visited by one or more species, presumably as sources of nectar; data not all from Michigan, although not usually identified geographically.]

Howard, Grace E. 1970. The lichen genus Ochrolechia in North America north of Mexico. Bryologist 73: 93-130. [Maps show locations for four species in Michigan, and selected specimens are cited. Unfortunately no explanation is included as to the herbarium symbols employed in the citations, which are not always the standard ones of Index Herbariorum.]

Kowalski, Donald T. 1970. The species of Lamproderma. Mycologia 62: 621-672. [*L. arcyrionema* cited from Washtenaw and Wayne Cos.; report of *L. sauteri* from Michigan considered doubtful; *L. carestiae* report from Michigan also mentioned.]

Liberta, Anthony E. 1969. Descriptions of the nomenclatural types of Corticium described by Burt. Nova Hedwigia 18: 215-233. [Includes comments on paratypes of *C. fuscostratum* from Michigan.]

Mirza, J. H., & R. F. Cain. 1969. Revision of the genus Podospora. Canad. Jour. Bot. 47: 1999-2048. [*P. curvula* cited from Michigan.]

Petersen, Ronald H. 1968. Type studies in the Clavariaceae. Sydowia 21: 105-122. [Type of *C. luteo-tenerrima* var. *borealis* from Pellston hills described in detail and referred to *C. inaequalis.*]

Pohl, Richard W. 1969. Muhlenbergia, subgenus Muhlenbergia (Gramineae) in North America. Am. Midl. Nat. 82: 512-542. [Distribution maps indicate Michigan occurrence for many of the taxa.]

Savile, D. B. O. 1970. Autoecious Puccinia species attacking Cardueae in North America. Canad. Jour. Bot. 48: 1567-1584. [Material from Michigan seen for several of the species; hosts indicated.]

Shaffer, Robert L. 1970. Cuticular terminology in Russula (Agaricales). Brittonia 22: 230-239. [*R. virescens* and *R. crustosa* cited from several Michigan localities.]

Smrchek, Jerry C. 1970. Craspedacusta sowerbyi: Northern extension of range in Michigan. Trans. Am. Micr. Soc. 89: 325-327. [Includes table of phytoplankton at the collection site of this jellyfish in Burt Lake, Cheboygan Co.]

Sparrow, F. K., & R. M. Johns. 1970. Observations on Chytridiaceous parasites of phanerogams XVII. Notes on a Physoderma parasitic on Asclepias incarnata. Arch. Mikrobiol. 70: 72-81. [From the vicinity of Douglas Lake.]

Sparrow, F. K. 1970. Observations on Chytridiaceous parasites of phanerogams XVIII. A Physoderma on Juncus pelocarpus Mey. Arch. Mikrobiol. 70: 104-109. [From Vincent Lake, Cheboygan Co.]

Stuckey, Ronald L., & Louis Phillips. 1970. Distributional history of Lycopus europaeus (European water-horehound) in North America. Rhodora 72: 351-369. [Includes records from Monroe Co.]

Thompson, Paul W. 1970. A wet prairie community in Ann Arbor, Michigan. Mich. Academ. 2(4): 87-94. [Report on a tract dedicated through cooperation with Michigan Natural Areas Council.]

Zasada, John C., & Robert Zahner. 1969. Vessel element development in the earlywood of red oak (Quercus rubra). Canad. Jour. Bot. 47: 1965-1971. [Material studied was from southeastern Michigan.]

News of Botanists

William C. Steere, President of the New York Botanical Garden, received the Mary Soper Pope Medal of the Cranbrook Institute of Science last August. The award for "noteworthy and distinguished accomplishment in the field of plant sciences" was presented by W. H. Wagner, Jr., a trustee of Cranbrook and president of the Michigan Botanical Club, at the annual banquet of the Botanical Society of America at Indiana University. In 1950 Dr. Steere left the chairmanship of the Department of Botany at his alma mater, The University of Michigan, for Stanford University, where he became dean of the graduate school in 1955. In 1958 he became director of the New York Botanical Garden.

* * * * * *

Recent deaths of two active members of the Michigan Botanical Club have been reported. Mr. Ovid P. Stancer, of Athens, Michigan, a member of the Big Tree Committee, died in Coldwater on August 31, 1970. He was a retired hydraulic engineer. Abby Beecher (Mrs. Alton True) Roberts died September 16 in Marquette. A founding member of the Club, she was a civic leader with an honorary degree from Northern Michigan University; she received the Robinson Medal of the Michigan Horitcultural Society in 1950.

* * * * * *

UNIVERSITY OF MICHIGAN BIOLOGICAL STATION

For information on the 1971 summer session, interested students and investigators may write for an Announcement to the University of Michigan Biological Station, Ann Arbor, Michigan 48104. In addition to research opportunities, formal botany courses to be offered include Plant Taxonomy (10 weeks), Boreal Flora, and Aquatic Flowering Plants (Voss), Bryophytes and Lichens (Crum), Higher Fungi (Shaffer), Algae and Phytoplankton (Stoermer), Ecology (Cooper and Phillips).

Editorial Notes

ERRATUM GRAVE: In the notice of the Oxford Book of Food Plants on p. 247 of the October issue, an inexplicable mental chiasma resulted in a completely erroneous scientific identification for the "kiwi fruit," which in fact is *Actinidia chinensis* Planch. (Actinidiaceae), also known as "Chinese gooseberry."

FEDERATION OF ONTARIO NATURALISTS: The cover photo for this issue has been made available through the courtesy of the Federation of Ontario Naturalists, in whose Newsletter (November-December 1968) it earlier appeared. In addition to the Newsletter, FON members receive a handsome quarterly, *Ontario Naturalist;* have an opportunity to join in campouts and field trips ranging from the Bruce Peninsula to Hudson Bay (and even to the Yukon); and actively support a vigorous conservation program in the province which shares so long (if watery) a border with Michigan. The FON annually sells an exceptionally handsome Christmas card. Members of the Michigan Botanical Club (and others) who want to be more closely associated with conservation and natural history efforts in a neighboring area may send dues to the Federation of Ontario Naturalists, 1262 Don Mills Road, Don Mills, Ontario ($3.00 student; $7.00 individual; $8.50 family).

The October number (Vol. 9, No. 4) was mailed October 7, 1970.

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CONTENTS

A Collection of Bryophytes from Summer Island, Delta County, Michigan
Norton G. Miller & Richard L. Halbert 3

The Distribution of Mosses in the Byron Bog, Southwestern Ontario
F. S. Cook 14

The Biosystematics and Ecology of the Genus *Brachyelytrum* (Gramineae) in Michigan
Stephen N. Stephenson 19

Back Issues Needed 33

Variability in Bark Morphology of Yellow Birch in an Even-aged Stand
Bruce P. Dancik & Burton V. Barnes 34

Isotria medeoloides, the Smaller Whorled Pogonia, in Michigan
Frederick W. Case, Jr., with William Schwab 39

Publications of Interest 43

Michigan Plants in Print 44

News of Botanists 46

Editorial Notes 47

(On the cover: An Ontario stream in winter. Photo by Karl Sommerer, 1964, for National Film Board of Canada. See p. 47.)

33
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Vol. 10, No. 2

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CHROMOSOME STUDIES ON THE SPRING BEAUTIES, *CLAYTONIA,* IN ONTARIO

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Over the past third of a century, much has been learned about the nature of plant species through studies of their chromosomes. Most plant species have uniform chromosome numbers, and it is exceptional to find more than one or two different numbers in a given taxon. Also, we usually find that the sporophytic or somatic chromosome number ($2n$) of a given plant is an even number, one set of chromosomes (n) contributed by the male gamete, one set (n) by the female gamete. The familiar Spring Beauties, *Claytonia caroliniana* Michx. and *C. virginica* L., are remarkable exceptions.

These two eastern species of *Claytonia* have many different cytotypes which appear to have a definite geographical pattern of distribution (Lewis, 1967; Lewis et al. 1967 a and b; Rothwell, 1959; Rothwell & Kump, 1965). Few cytological studies have been carried out on *C. caroliniana* and *C. virginica* in the northern parts of the ranges of the two species. Thus, while much is known of the cytotypes and their distribution south of New York and Indiana, information from north of these states is scattered and incomplete. The northern region, however, is perhaps the most interesting as it includes a large band in which the two species are sympatric and thus can be studied in mixed populations (Voss, 1968). In our study to be described here, chromosome numbers were determined from twelve locations in Ontario, both in the region of overlap and north and south of it where the two species occur separately. Two of these locations have mixed populations, one in Lambton County (Voss, 1968) and the other in Halton County. Of the others, six sites had only *C. caroliniana* present and four had only *C. virginica.* Specimens for morphological data were gathered at a later date from five sites: two sites for each species and one site for a mixed population. From all but one of these sites, the plants were cytologically studied.

MATERIALS AND METHODS

The whole plant except for the corm and roots was collected early in April for meiotic studies. The plants were fixed in 3:1 (absolute ethyl alcohol–glacial acetic acid) for about one week, then stored in 70% ethyl alcohol until studied. Anthers were stained and squashed in 2% propiono-orcein and selected slides were made permanent by inverting them in a petri-plate containing absolute ethyl alcohol and then replacing the fallen coverslip on a drop of Euparol. The photographs were made from the permanent slides. Plants for morphological data were all gathered from various localities on May 19 (except one sample of *C. caroliniana* from Simcoe County collected May 14). These were pressed in the usual manner; later the leaf length/width ratio and

TABLE 1. Chromosome numbers of *Claytonia* in Ontario.

Location*	Species	No. of Plants Determined	n†	Number of Plants
1. Halton Co., Campbellville	C. caroliniana	2	9	2
	C. virginica	7	8	7
2. Lambton Co., Thedford	C. caroliniana	5	8	5
	C. virginica	19	8	10
			9	4
			8,9	5
3. Norfolk Co., Simcoe	C. virginica	12	8	9
			11,12	1
			12	2
4. Perth Co., Avonton	C. virginica	2	10	2
5. Simcoe Co., Innisfil Tp.	C. caroliniana	2	8	2
6. Simcoe Co., Vespra Tp.	C. caroliniana	2	8	2
7. Simcoe Co., Wye Marsh	C. caroliniana	1	8	1
8. Waterloo Co., Hespeler	C. caroliniana	1	8	1
9. Wellington Co., Corwhin	C. caroliniana	2	8	2
10. Wellington Co., Morriston	C. caroliniana	3	8	3
11. Wellington Co., Puslinch Lake	C. virginica	7	8	7
12. Wellington Co., Opp. Little Tract	C. virginica	5	8	5
Published Records:				
13. Peel Co., Credit Forks (Lewis, 1967)	C. caroliniana	2	8	2
14. Wentworth Co., Royal Bot. Gardens (Lewis et al., 1967b)	C. virginica	2	8	1
			9	1
		Total plants		74

†n is the gametophytic or haploid chromosome number determined at meiosis.

*Location and date of collection:

1. Conc. V, lot 6, Nassagaweya Tp., Halton Co., April 3, 1970.
2. Conc. VI, Military Grid Ref. 271767, Bosanquet Tp., Lambton Co., April 7, 1970.
3. Conc. III, lot 14, Woodhouse Tp., Norfolk Co., April 5, 1970.
4. Conc. VII, lot 14, Downie Tp., Perth Co., April 7, 1970.
5. Conc. X, lot 4, Innisfil Tp., Simcoe Co., April 17, 1970.
6. Conc. IX, lot 15, Vespra Tp., Simcoe Co., April 18, 1970.
7. Conc. III, lot 15, Tay Tp., Simcoe Co., April 20, 1970.
8. Conc. IV, lot 9, Waterloo Tp., Waterloo Co., April 4, 1970.
9. Conc. XI, lot 19, Puslinch Tp., Wellington Co., April 4, 1970.
10. Conc. VII, lot 29, East Puslinch Tp., Wellington Co., April 4, 1970.
11. Conc. II, lot 5, Puslinch Tp., Wellington Co., April 4, 1970.
12. Conc. III, lot 6, Puslinch Tp., Wellington Co., April 4, 1970.

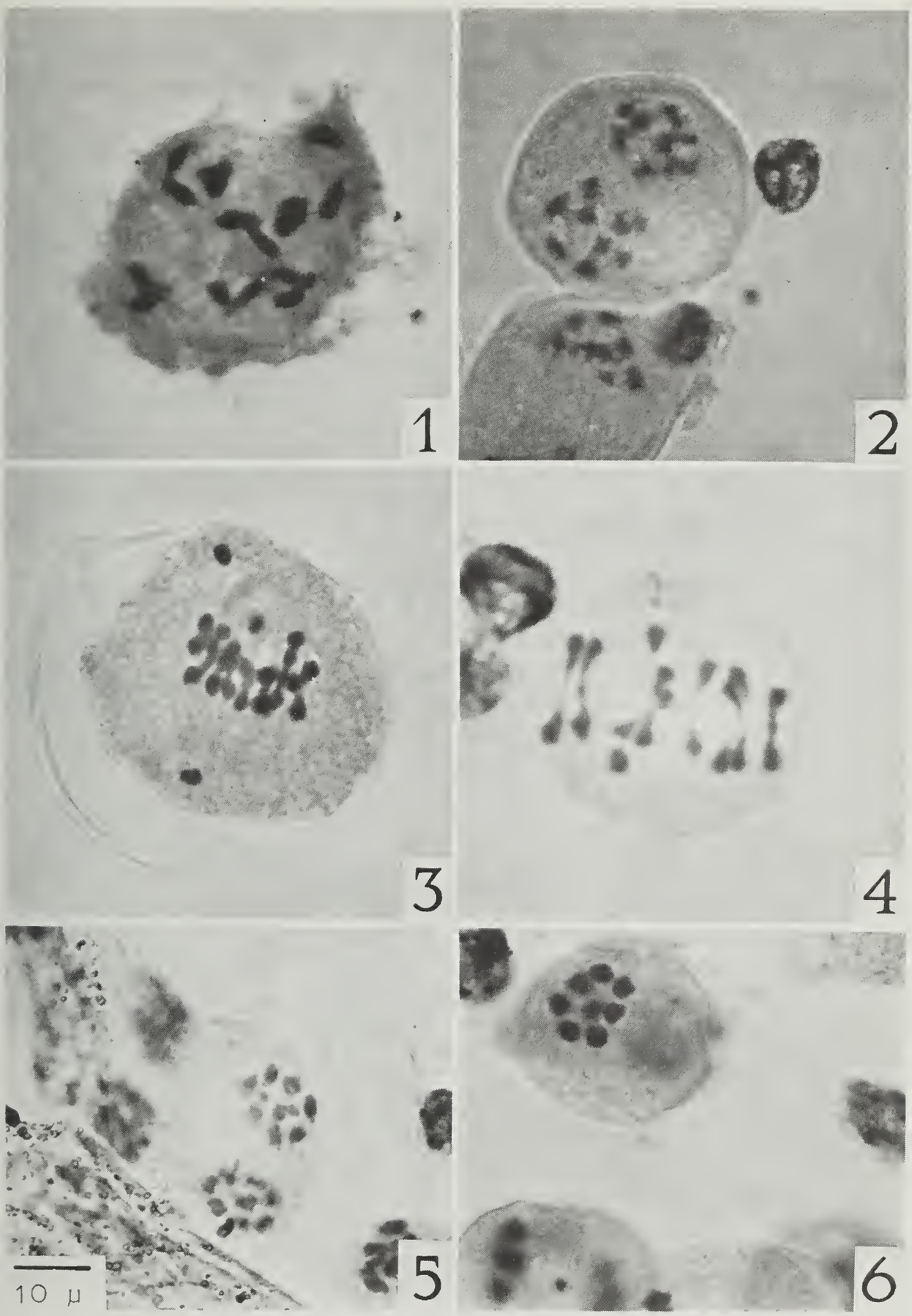

Fig. 1. *C. caroliniana,* Vespra Tp., Simcoe Co., diakinesis, *n*=8.
Fig. 2. *C. caroliniana,* Campbellville, Halton Co., interphase, *n*=9.
Fig. 3. *C. virginica,* Simcoe, Norfolk Co., metaphase I, *n*=12.
Fig. 4. *C. virginica,* Thedford, Lambton Co., metaphase I, *n*=9.
Fig. 5. *C. virginica,* Avonton, Perth Co., telophase I, *n*=10.
Fig. 6. *C. virginica,* opposite Little Tract, Wellington Co., telophase I, *n*=8.

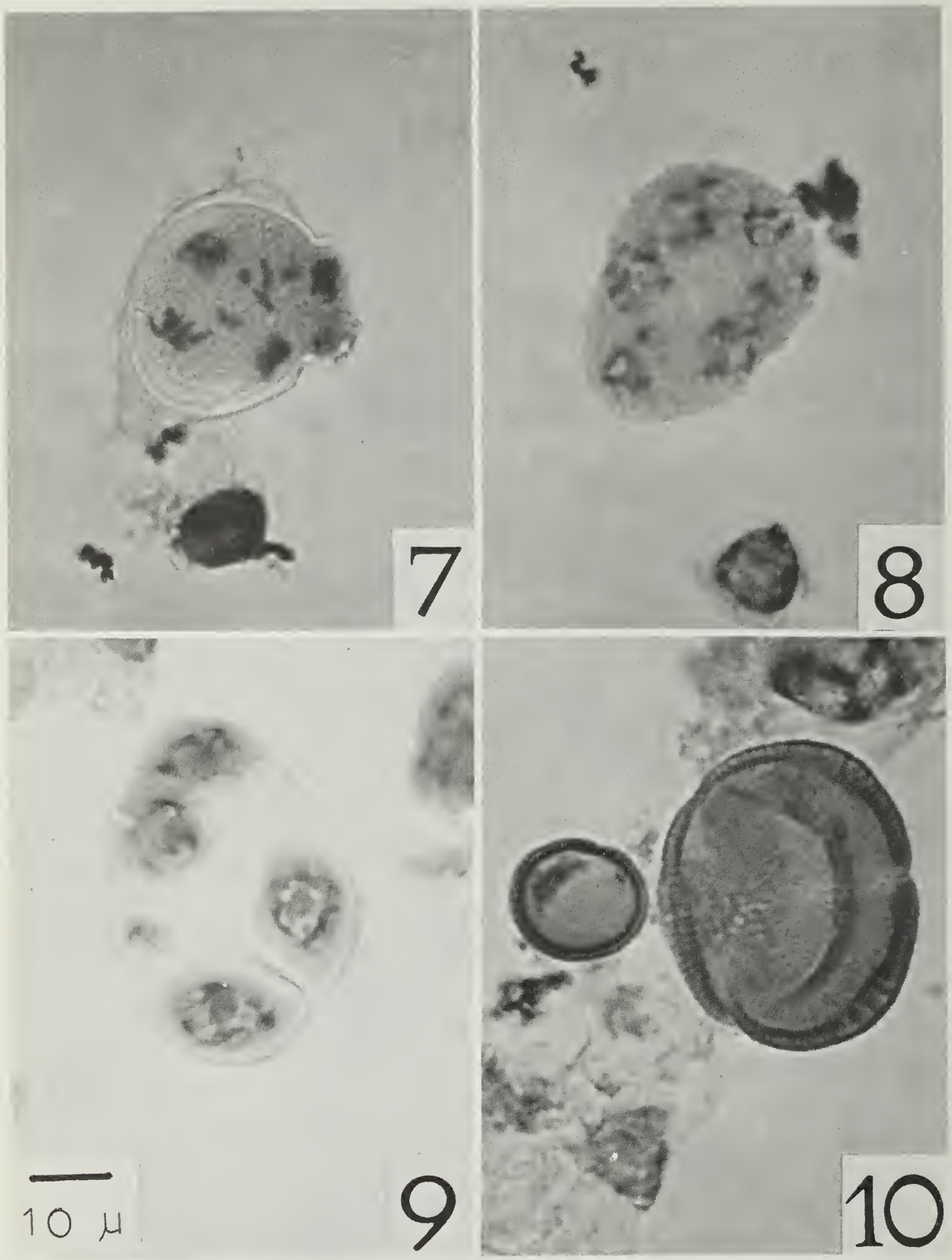

Fig. 7. *C. caroliniana,* Campbellville, Halton Co., irregular telophase II.
Fig. 8. *C. caroliniana,* Campbellville, Halton Co., interphase with three large groups of chromosomes and three small groups.
Fig. 9. *C. virginica,* Simcoe, Norfolk Co., Pentad with four nuclei of normal appearance and one micronucleus.
Fig. 10. *C. caroliniana,* Campbellville, Halton Co., large pollen grain of normal appearance and small, abnormal pollen grain.

the number of flowers per plant were determined. Vouchers were deposited in OAC.

The distribution maps (Figs. 11 and 12) were compiled from selected specimens in OAC, TRT, and UWO as well as from a few literature records considered to be authentic. An attempt was made to avoid overlapping dots. The final picture of the distribution of these two species is meant to show the broad trends in Ontario with *C. virginica* in the south and with a few scattered more northern locations, as is true in Michigan (Voss, 1968). By comparing Figure 11 and Figure 12, the regions where the two species overlap in their distribution should be evident.

CYTOLOGICAL RESULTS

The chromosome number determinations are given in Table 1 and are illustrated in Figure 1-6.

DISCUSSION

It was made certain that at least three or four and usually over ten exceptional cells that could be easily counted were observed per plant before using it in the sample. Due to the extreme earliness of *C. caroliniana,* it was difficult to find plants that were not either past meiosis or covered by snow. Accordingly, sampling this species was much more difficult than *C. virginica,* which has a later meiosis. Thus fewer plants are recorded in the samples for the former species.

From Table 1, it is evident that n=8 is by far the most common number for both species in Ontario, with all but one locality for *C. caroliniana* having this number. Most *C. virginica* have n=8 as well. The other chromosome number for *C. caroliniana* is n=9 recorded from one locality. However, with *C. virginica,* there have been recorded two locations with n=9 plants present with n=8 plants, one with n=8, 11-12, and 24, and also a colony of n=10 plants. Therefore, *C. virginica* in Ontario, is as reported elsewhere (Lewis et al., 1967b), more variable in chromosome number than *C. caroliniana.*

It is interesting to look at the distribution in Ontario of the various chromosome numbers. In central southern Ontario, *C. caroliniana* growing north of the range of *C. virginica* is a constant species with plants from all stations examined having $2n$=16 (8 bivalents).[1] A band extending from Toronto through Guelph to northern Lambton County is the approximate southern limit of *C. caroliniana* (Fig. 11), and in this area one colony of $2n$=18 (9 bivalents) was found. *C. virginica* on the other hand, reaches its northern limit in Ontario in approximately this band, being rare north of it (Fig. 12). In this region it is a fairly constant species with $2n$=16 (8 bivalents), although one colony at Avonton, Perth County, had a $2n$ number of 20 (10

[1] $2n$ is the somatic chromosome number which has been derived from the gametic numbers (n) by adding the numbers of chromosomes seen at each pole of Anaphase I or at Interphase. If only bivalents are observed at Diakinesis and Metaphase I, $2n$ is obtained by doubling the number of bivalents. A plant with 8 chromosomes at one pole and nine at the other at Anaphase I, presumably had 17 chromosomes in its somatic cells.

bivalents) and the Thedford colony had plants with $2n$= 16, 17, and 18. It is in this region that mixed populations are found and plants were collected and examined from two sites, one near Thedford mentioned above, and one near Campbellville in Halton County. At this last site, *C. virginica* had eight bivalents and *C. caroliniana* had nine bivalents but no cytological intermediates were found. Below this approximate band, *C. virginica* occurs alone and is variable in chromosome number, e.g. a colony at the Royal Botanical Gardens in Hamilton had plants with both 8 and 9 bivalents (Lewis et al., 1967). In a colony near Simcoe in Norfolk County, there were plants with n=8 as well as plants with $2n$=23 and 24 (Figs. 3 & 9). However, the distribution of the chromosomes at metaphase and anaphase I is irregular in the

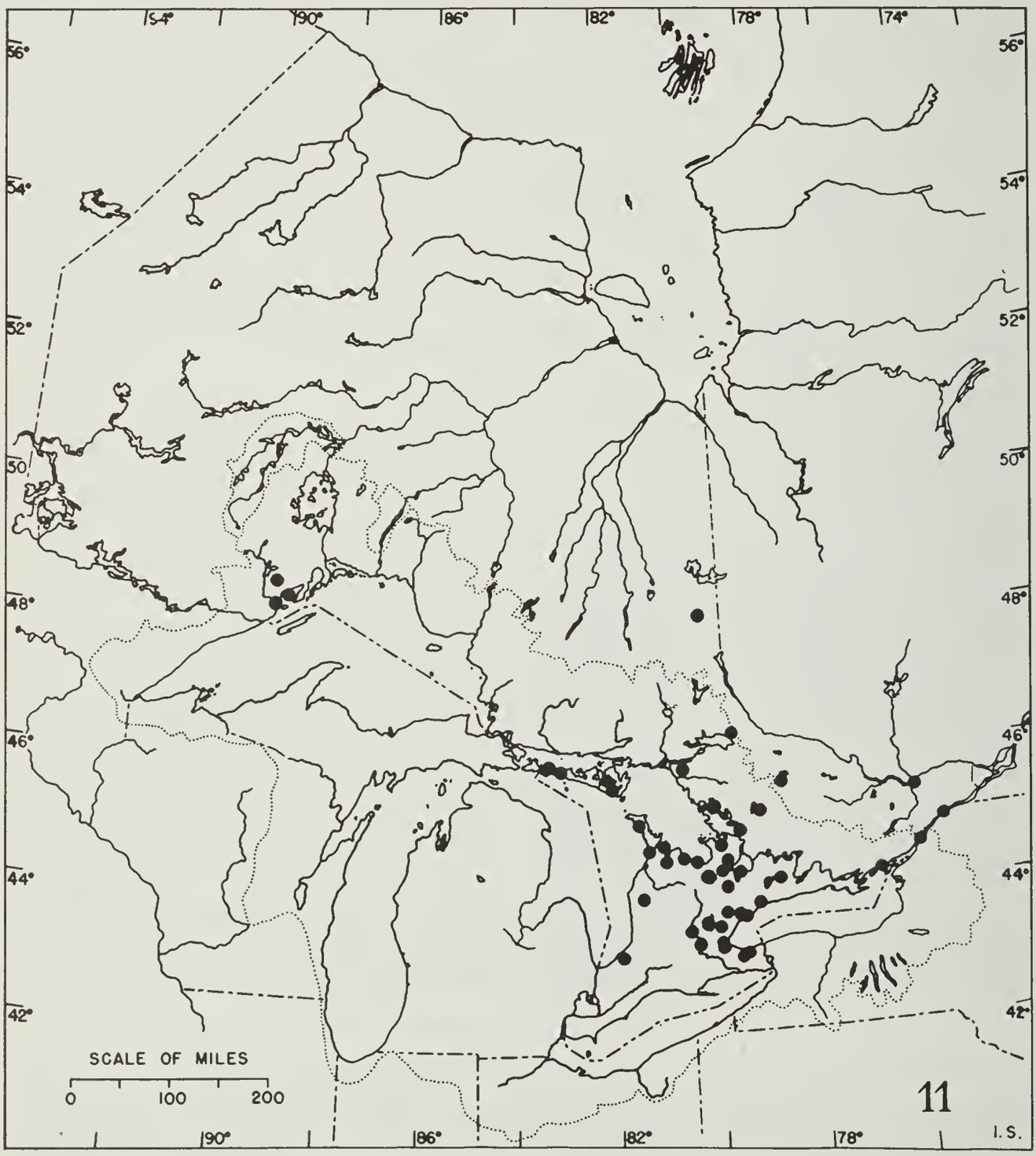

Fig. 11. Distribution of *C. caroliniana* in Ontario

plants with $2n$=24. It is possible that there are univalents present, but from observations of metaphases and anaphases of many cells one can see that some metaphases have none of these "univalents" and some have many. Probably there is a sequence from early metaphase where none appear to late metaphase where many appear. Thus it is probably more likely that there are twelve bivalents but with asynchronous separation so that some bivalents separate before others. These separated bivalents are displaced from one another during the squashing procedure resulting in a cell that appears to have isolated univalents. The final way of settling this would be to observe the diakinesis stage of meiosis in these plants as in Figure 1 where the bivalents are well spaced and each bivalent is held together by a terminalized chiasma. However, diakinesis was not observed in the plants examined.

Of the recorded numbers, the $2n$=16 number for *C. caroliniana* is common but the $2n$=18 number is an uncommon one not listed in a summary of numbers given in Lewis (1967). Of the numbers for *C. virginica,* $2n$=16, 18, and 24 are not uncommon, but $2n$=20 is a rare number and none with the regular 10 bivalents have been recorded before (Fig. 1-6). The complement of these plants is interesting. There are eight large bivalents and two small ones. This suggests a local origin of this number by centric fission in n=8 or n=9 populations of *C. virginica.*

Thus it seems that different cytotypes of *C. caroliniana* and *C. virginica* are present in Ontario as elsewhere, although to a lesser extent than further

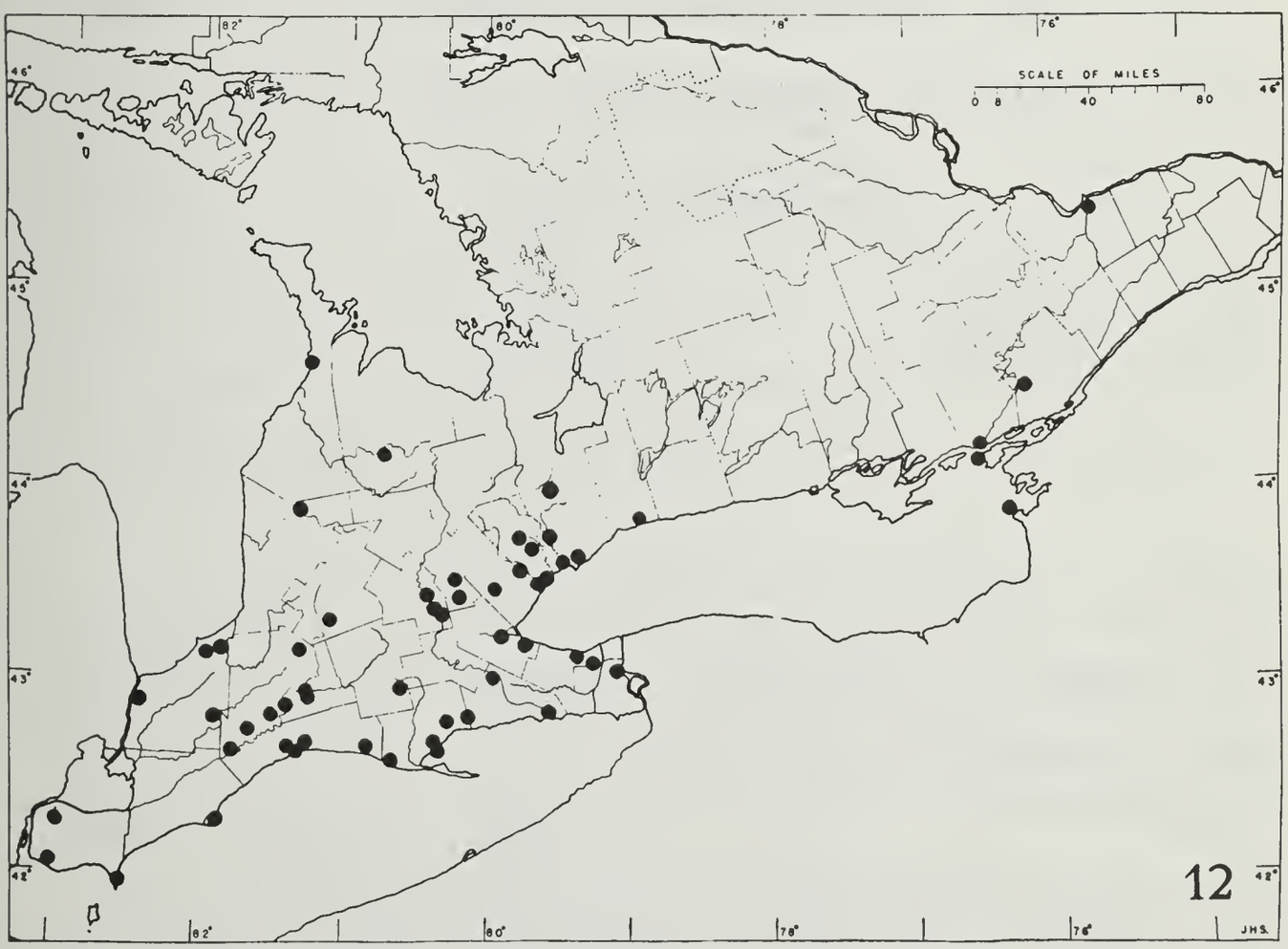

Fig. 12. Distribution of *C. virginica* in Ontario.

south in the central and southern United States, where fifty cytotypes ranging from $2n$=12 to $2n$=ca. 191 are found for *C. virginica* (Lewis et al., 1967b; Lewis, 1970). This species has a widespread range over central and southern United States from Kansas eastward, and south from Minnesota to Texas. Seven cytotypes ranging from $2n$=16 to $2n$=38 are known for *C. caroliniana,* which is much less widely distributed, being found only in the Appalachian region, southeastern Canada, and northeastern United States. The variations in chromosome number are correlated with the distribution from north to south in Ontario. From north to south in the range of *C. virginica* especially, there seems to be an increase in the $2n$ number from a regular $2n$=16 in the northern part of the range to a high of $2n$=24 in the very southern part of Ontario. This sort of clinal variation has been hinted at, by a very few counts of $2n$=16, 24, 26, and 28 from Michigan, Wisconsin, and Iowa with the numbers increasing as one moves from north to south (Lewis et al., 1967b). However, only eight localities have been examined for these three large states so that a complete survey has not yet been made.

MORPHOLOGICAL STUDIES

The studies on leaf length to leaf width and number of flowers for the two species are summarised in Tables 2 and 3.

It may be seen that leaf length/width ratios are a very reliable way of distinguishing the two species in Ontario. There is almost no overlap in the ratios, and there is a large difference in the means: 16.67 in *C. virginica,* as

TABLE 2. Leaf length/width ratios and numbers of flowers in *C. caroliniana.*

Location	Number of Plants Sampled	Leaf Ratio	Mean	Mean No. of Flowers	*n*
Halton Co., Campbellville	6	4.33-9.33	6.18	6.16	9
Simcoe Co., Innisfil Tp.	2	4.23-6.88	5.45	4.50	8
Wellington Co., Morriston	4	5.09-10.00	6.86	7.75	8
Totals	12	4.23-10.00	Mean 6.16	Mean 6.13	

TABLE 3. Leaf length/width ratios and numbers of flowers in *C. virginica.*

Location	Number of Plants Sampled	Leaf Ratio	Mean	Mean No. of Flowers	*n*
Halton Co., Campbellville	13	11.00-25.00	17.26	6.84	8
Wellington Co., Puslinch Lake	8	9.00-21.33	16.34	6.62	8
Wellington Co., Little Tract	15	8.75-30.25	16.42	6.60	–
Totals	36	8.75-30.25	Mean 16.67	Mean 6.68	

compared with 6.16 in *C. caroliniana.* The overlap that did occur in this study came from only a few plants. In these cases, this resulted from a wide, but still linear to lanceolate and petiole-less *C. virginica* being compared with a narrow, but still rhomboid and long-petioled *C. caroliniana.* Thus, even with identical length/width ratios, the leaves can be of drastically different shapes. This single constant feature allows one to separate the two species.

Although it has been stated that *C. virginica* has a larger inflorescence than *C. caroliniana,* this has not been substantiated by the present study. The two means of numbers of flowers (6.68 for *C. virginica* and 6.13 for *C. caroliniana*) are not sufficiently distinct for use. It is true, however, that *C. virginica* will sometimes grow in sunny spots such as open glades and woods where the trees have died, and even grassy roadsides. In these sunny locations the plants are very robust with large corms, long linear leaves and very large inflorescences; the number of flowers being much larger than the maximum for *C. caroliniana* which shuns sunlight and is never found in exposed locations. When the two are growing together in a mixed population, however, there is no observable difference in the size of the inflorescence.

The character of the bract below the inflorescence, whether herbaceous or scarious, has been used as a character in some keys but it has been shown by Voss (1968) to be unreliable. Other differences, for example in seed size, flower size and sepal shape, although probably bimodally distributed, proved unreliable and of little use as identification characters.

GENERAL OBSERVATIONS AND DISCUSSION

In making the pollen mother cell squashes of material of the two species, it soon became obvious that from the same site, *C. caroliniana* undergoes meiosis before *C. virginica.* Also, the raceme of *C. caroliniana* is less regular in sequence, and often the next bud younger than one with tetrads or young pollen grains is in pachytene. Consequently, meiotic figures suitable for counting would be unavailable. This may, however, be merely because most of the *C. caroliniana* was collected a little too late for meiosis in the first few buds. However, as mentioned previously, any attempts at earlier collection would run into the difficulty of snow cover. It should be noted that buds of *C. caroliniana* which are at the same meiotic stage as those of *C. virginica* are significantly smaller and are therefore much more difficult to dissect.

In the plants studied meiotically, there did not seem to be any morphological indication of chromosome number in the leaf size, shape, size of raceme, and size of buds of either species. Consequently, the various cytotypes could not be distinguished except by counting the chromosomes. Differences may develop or show up as the plants mature and flower, but other workers have not found any consistent differences except perhaps in leaf width in *C. virginica.* However, even this character is not suitable for all populations (Lewis et al., 1967a).

An interesting observation was made on plants from the mixed population at Campbellville. Here, *C. caroliniana* has the unusual number of $2n=18$, while *C. virginica* has the common number of $2n=16$. Meiotic division I in *C.*

caroliniana is regular with the formation of nine bivalents, but at meiotic division II an amazing amount of irregularity was observed. A high percentage of plants have one or more lagging chromosomes and fragments (Fig. 7). A few cells were observed which had aberrant meiotic spindles which formed three or four metaphase plates of various sizes. Some contained only two or a few chromosomes and others nearly the full complement. The causes of these abnormalities are not known. Previously reported $2n=18$ plants of *C. virginica* had no reported irregularities and a reasonably good pollen fertility of sixty percent (Rothwell, 1959). However, *C. caroliniana* plants with $2n=18$ may be more unstable. Also, perhaps important, is the fact that plants with this number and showing irregularities in meiosis II were taken from an intimately mixed population with *C. virginica.* Perhaps hybridization has somehow contributed to the origin of this cytotype and is in some way causing its instability, rather than the cytotype having been produced by aneuploidy from a $2n=16$ cytotype as is thought to occur for $2n=18$ populations of *C. virginica* (Lewis et al., 1967b).

Following telophase II, the nuclear membrane reforms around these lagging chromosomes and also around fragments and groups of chromosomes (Fig. 8). This results in pentads, hexads, septads, or even octads of various sizes rather than tetrads (Fig. 9). This formation of micronuclei from lagging chromosomes has been observed in natural triploids of Bermuda grass (*Cynodon dactylon* (L.) Pers.) by Gupta and Srivastava (1970). The percentage of meiotic irregularities can be determined from the percentage of the abnormal "tetrads" (Table 4). The irregular "tetrads" were mostly five- and six-nucleate; few seven- and very few eight-nucleate "tetrads" were found. Seemingly the same phenomenon has been observed to a much lesser extent in the population of *C. virginica* in Norfolk Co.

TABLE 4. Random sampling of twenty* meiotic products showing the distribution of numbers of nuclei.

	Numbers of nuclei				
	4 (normal)	5	6	7	8
Numbers Seen	5	7	6	2	0
Percent	25	35	30	10	0

*Although the sample size is small, and only two abnormal plants were studied, the percent irregularities is approximately 75.

All the nuclei found in the "tetrads" form pollen grains. Accordingly, an abundance of tiny pollen grains, obviously non-viable since they contain only one or a few chromosomes, as well as a few in-between-size pollen grains that contain a larger number of chromosomes than one or two, but less than the normal nine; and the also common slightly smaller pollen grains probably containing seven or eight chromosomes are produced (Fig. 10).

In the *C. virginica* population from this site and the *C. caroliniana* and *C. virginica* populations from other sites, the only meiotic irregularities observed in meiotic division II were bridges, which were uncommon, and laggards, which were very rare. Unfortunately, no pollen viability tests were carried out on the plants of this anomalous population, but probably the pollen grains deficient for only one chromosome, or perhaps even those deficient for two, would be viable, and able to give rise to new cytotypes. Even if they are viable however, it would remain to be seen if they could actually complete the process of fertilization or compete with normal pollen.

Another interesting feature of the meiosis of these plants is that after the chromosomes arrive at the poles and anaphase I ends, they spread out in telophase I and become quite separate (Fig. 6). Then, gradually the chromosomes become less distinct but still separate as interphase begins. The chromosomes can thus be counted, if one is careful, as separate heterochromatic bodies quite far into the interphase (Fig. 2). This is a good stage for counting chromosomes although it is best to substantiate the counts with observations at metaphase and anaphase.

CONCLUSIONS

The somatic chromosome numbers found for *C. virginica* in Ontario are 16, 17, 18, 20, 23, and 24. The $2n=20$ number is rare and in that population the chromosomes are distributed as ten bivalents at meiotic division I. There are eight large bivalents and two small ones, perhaps indicating their origin by centric fission. The $2n$ numbers found for *C. caroliniana* are 16 and 18. The $2n=18$ plants have nine bivalents. This number is rare and has apparently not been recorded in this species before.

The chromosome numbers of *C. virginica* follow a distinct distribution pattern with more variation and a higher number in extreme southern Ontario than at the northern limit of the species. The only different number for *C. caroliniana* was also recorded near the southern limit of its range in Ontario. *C. caroliniana* is much less variable in cytotype than *C. virginica* and both species are less variable in Ontario than further south in central and southern United States.

Mixed populations are to be found in the Kingston area and in a band from Toronto to northern Lambton County. No hybrids have been identified in the two mixed sites examined. The difficulty of recognizing hybrids of two such morphologically similar species is realized. In these mixed populations, *C. caroliniana* undergoes meiosis earlier than *C. virginica* and also the meiotic buds are smaller. The two plants bloom at approximately the same time however. At one mixed site, plants of *C. caroliniana* with $2n=18$ showed a great deal of meiotic irregularity with lagging chromosomes, fragments, and other irregularities leading to the formation of micro-nuclei and tiny sterile pollen grains as well as larger ones deficient in one or two chromosomes. However, most populations of *Claytonia* in Ontario undergo a regular meiosis. Their meiosis has an interphase with conspicuous and separable chromosomes between the two meiotic divisions.

In separating the two species, the only good constant morphological characters are the leaf length/width ratios and the leaf shape. No other easily usable differences were noted.

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Review

THE ARCHAEOLOGY OF MICHIGAN. A Guide to the Prehistory of the Great Lakes Region. By James E. Fitting. Natural History Press, Garden City, N. Y. 1970. 274 pp. $18.95.

The author describes this work as "a progress report of what is going on in Michigan archaeology." Until recently Curator of Great Lakes Archaeology at the University of Michigan Museum of Anthropology and editor of *The Michigan Archaeologist,* he was in an excellent position to summarize the intense local activity of the past decade by The University of Michigan, Michigan State University, Wayne State University, and others. Chapter II, "Environments of Michigan," is background for the book's "ecological approach to Michigan prehistory," and attempts to summarize very briefly the geological history, waters, climate, soils, and even plants and animals of Michigan. The information on crops and native plants in the economy of native peoples will be of interest to botanists, although almost impossible to locate from the index, which does not include plant names nor even the word "crops"–the first word in the title of a 50-page chapter; the index is almost 100% restricted to proper nouns (names of persons, places, and archaeological sites). An appendix, "Michigan Radiocarbon Chronology," is a valuable feature. The work is handsomely illustrated with 123 figures, many of them depicting more than one object. The frequently used base map indicates Isle Royale as an independent county, resulting in a misleading list of 84 (rather than 83) counties–one of which (Mackinac) is consistently misspelled in both legend and text.

An attractively illustrated synthesis such as this would be of great educational value in the libraries of schools, summer camps, and individuals who need modern information on the archaeology of a state largely neglected in previous archaeological texts. It is unfortunate that the volume is so outrageously priced that those who could benefit from it will probably not consider it a prudent investment of funds.

–E. G. V.

NOTES ON THE FUNGAL ASSOCIATION OF TWO *MONOTROPA* SPECIES IN MICHIGAN

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INTRODUCTION

During the summer of 1968 I investigated the fungal association of *Monotropa uniflora* L. and of *Monotropa hypopithys* L. in northern Michigan. In both species of *Monotropa* there are erect, above-ground flowering stems which from visual observation lack chlorophyll. The underground portion of flourishing plants consists of a compact and roughly spherical cluster of short fleshy roots which grow interwoven with the fine roots of forest trees. Some of these flourishing plants were selected for examination. As noted by Francke (1934) for *M. hypopithys,* a different form with a much extended, slender root-system is found in areas where the food supply is either deficient or depleted.

The anatomy of both species of *Monotropa* is well known. The main points are summarized by Solereder (1908). The biology has also been the subject of several studies the results of which are summarized by Harley (1969). Björkman (1960), working in Sweden, showed the dependence of *M. hypopithys* on the roots of neighboring trees, for by isolating *Monotropa* plants by circles of sheet metal he found that only weak regrowth occurred in the following year. He also demonstrated the transfer of carbohydrate to *Monotropa* plants from adjacent trees of spruce and pine whose phloem had been injected with D - glucose - ^{14}C, and a similar transfer of ^{32}P from pine to *Monotropa* but only insignificant transfer to *Calluna* or *Vaccinium.* Björkman isolated a fungus from *Monotropa* roots which he found capable of forming a typical ectotrophic mycorrhiza with pine and possibly with spruce although in the latter the Hartig net was not distinguishable. He interpreted *Monotropa* as an epiparasite attaching chiefly to forest trees through its mycorrhizal fungus. Francke (1934) considered that the fungus involved with *M. hypopithys* was a species of *Boletus* but Björkman found that the morphology of his isolate was different from the three *Boletus* species which he examined.

METHODS OF INVESTIGATION

The methods used in the present investigation consisted firstly of examination of plants in the field and after careful removal of litter attempting to follow root systems and fungal strands. In many areas where *Monotropa* occurs the roots of various species of trees are inextricably interwoven. However, areas selected for investigation were those where trees of a single species occurred in groves. It was then possible to follow the root system of

the trees through the soil and amongst a preponderance of roots of one species to recognize more readily any roots of other species, even though they were far removed from the base of their respective trunks. In this way it was possible to determine with which trees the *Monotropa* plants were associated. As well, portions of soil including selected *Monotropa* plants were dug out with a spade and transported to the laboratory. Here the soil was carefully removed by using forceps and by washing with water. The fleshy roots of the *Monotropa* were then readily distinguishable from the roots of trees which grew interwoven amongst them. As far as possible any fungi present were followed in their ramifications through the soil and in their attachments to the roots of plants. In order to establish the behavior of the fungi within the roots, small cubes containing selected portions of *Monotropa* root together with portions of adjacent tree roots were killed and fixed in formalin-acetic-alcohol; later these portions were embedded in paraffin and sectioned by microtome. Staining of the sections with safranin and fast green gave satisfactory contrast.

INVESTIGATIONS ON *MONOTROPA UNIFLORA*

M. uniflora grows in woodland humus both in North America and in Asia. In northern Michigan it grows under a wide range of trees and is obvious above-ground in July and August when the plants are in flower. Of the 30 plants selected for investigation 3 came from under *Fagus grandifolia* Ehrh., 19 from under *Acer saccharum* Marsh., 2 from under *Quercus rubra* L., 3 from under *Pinus strobus* L., and 3 from under *Tsuga canadensis* (L.) Carr.

The root of *Monotropa* when examined in sections shows an appearance similar to an ectotrophic mycorrhiza of beech or pine, for the fungus makes a sheath-like mantle and penetrates between the outermost cortical cells in the form of a Hartig net. Single hyphae penetrate the outermost cells and grow towards the nucleus where the hyphal tip becomes swollen and bladder-like and then releases its contents. Furman (1966) reports the mycelium on *Monotropa* to be septate and without clamp connections.

In all of the samples examined brown rhizomorphs of *Armillaria mellea* (Vahl ex Fr.) Kummer were found to be present. These were up to 1.5 mm in diameter and could be followed in one direction into rotting wood which had accumulated where trees had been felled. In the opposite direction they could be followed into narrower white strands which were of a maximum diameter of 0.5 mm. Some of these strands grew amongst the roots of the *Monotropa* and could be followed right to the fungal mantle on the *Monotropa* roots. Others could be followed to the surface of tree roots which grew interwoven with the *Monotropa.* These tree roots were of an average diameter of 0.5 mm. In *Acer saccharum* near which the largest rhizomorphs occurred the fungus was found to form a compact investment on the surface of the epidermis or of the bark, although never appearing as an ectotrophic mycorrhiza with a Hartig net; but in the other tree species the fungus merely made contact with the root. The location of the fungal strands showed both

in dissections and in microtomed sections. In all cases hyphae also penetrated the tree roots. If the roots were alive, the fungus either grew in the cortical cells and destroyed their protoplasts or grew between the bark layers. If the roots were dead, the fungus penetrated the vascular cylinder as well.

INVESTIGATIONS ON *MONOTROPA HYPOPITHYS*

M. hypopithys grows in woodland humus in North America, Europe, and Asia. In northern Michigan the plants are obvious in June and July when they are in flower. They are found under several different kinds of trees. Of the 10 plants examined 2 were collected from under *Betula papyrifera* Marsh., 3 from under *Picea glauca* (Moench) Voss, 2 from under *Populus grandidentata* Michx., and 2 from under *Populus tremuloides* Michx. *M. hypopithys* has been studied much more fully than the previous species, particularly by workers in Europe who investigated plants from forests of pine, spruce, or beech.

In section, the root of *M. hypopithys* resembles that of *M. uniflora* in that there is a sheath-like fungal mantle with hyphae penetrating between the outermost cells in the form of a Hartig net and also entering the outermost cells. Here they yield up their content as described in detail by Francke (1934).

When the *Monotropa* is growing under *Populus tremuloides,* a fungus occurs amongst the roots as single hyphae and as strands up to 200 μ in diameter. The strands also occupy the central cavity of decayed mycorrhizal roots of *P. tremuloides* or the xylem cavities of decaying main roots. Often the strands have an outer brown to black pseudoparenchymatous layer composed of thick-walled hyphae of diameter up to 4.5 μ, but most of the hyphae are thin-walled and of diameter 1.5 to 3 μ. They are septate without clamp connections. In young roots of *P. tremuloides* the fungus at first takes the form characteristic of an ectotrophic mycorrhiza with the fungus making an external mantle and penetrating along the walls of the outermost cells as a Hartig net. The outermost cells of the root tend to become radially elongate. Later the fungus penetrates into the cortical cells and in most of the roots near the *Monotropa* these cells soon die. A cork cambium arises in the pericycle and forms a layer of cork as the cortex collapses.

Under one of the *Picea* trees in Reese's Bog near the University of Michigan Biological Station and under one near Lake Huron there were fungal strands up to 60 μ in diameter and also single hyphae amongst the *Monotropa* roots. Most of these hyphae are thin-walled and of diameter 1.5 to 3 μ, but isolated thick-walled brown hyphae are of diameter 3 to 4.5 μ. The fungus also forms an investment on the fine roots of the *Picea* and penetrates along the walls throughout the cortex. The cortical cells do not alter in size and soon die. Similar hyphae to those on the *Monotropa* (under *P. tremuloides* and *Picea*) were found in strands coming from the base of sporophores of *Clitocybe squamulosa* (Fr.) Kummer collected in the same area, but a direct connection of the sporophores to the mantle on the *Monotropa* roots was not observed.

Under another *Picea* tree in Reese's Bog there was apparently a different fungus amongst the *Monotropa* roots, for the hyphae were 3 to 4.5 μ in diameter, a few showed clamp connections, and some had segments with slightly inflated ends. This fungus infects the *Picea* roots in the same manner as the fungus mentioned previously.

When the *Monotropa* was growing under *Populus grandidentata,* a fungus occurred amongst the roots as single hyphae and as white strands of a diameter up to 36 μ. The hyphae of this fungus are septate without clamp connections and have a diameter of 2.5 to 4.5 μ They tend to branch at a wide angle and interweave with one another. Segments of some of the wider hyphae have somewhat inflated ends. The fine roots of *P. grandidentata* near the *Monotropa* have the typical form of an ectotrophic mycorrhiza. The outermost cells of these roots enlarge radially to give a radial diameter up to 3 times the tangential diameter. Later the cortical cells die. In roots which persist a cork cambium arises in the pericycle and in older roots the fungus may be present between the flaking layers of cork. *Betula papyrifera* was found to have a similar infection and differs from *P. grandidentata* only in that there is no formation of cork in the roots near the *Monotropa.*

DISCUSSION

The fungus associated with *M. uniflora* in northern Michigan is also parasitic on the roots of adjacent trees as evidenced by its destruction of cortical cells. In all of the specimens examined the fungus was found to be *Armillaria mellea,* whose rhizomorphs are readily recognizable. On the other hand the fungus associated with *M. hypopithys* in northern Michigan appears as a component of an ectotrophic mycorrhiza on neighboring trees, although it does not form a completely harmonious association with the tree roots whose cortical cells soon die. The fungus appears to be one or another of several species judging from the morphology of hyphae and fungal strands. All apparently differ from the fungus associated with *M. hypopithys* in Europe, which was investigated by Francke (1934), for he found the hyphae of the mantle to be 3.5 to 5.5 μ in diameter. The situation in the genus *Monotropa* thus parallels that in *Gastrodia,* where one species is associated with a fungus which is also involved in a mycorrhiza with *Leptospermum scoparium* (Campbell, 1963) and other species are associated with *Armillaria mellea* (Kusano, 1911; Campbell, 1962).

Since *Armillaria mellea* has been studied extensively in culture, its growth-forms and behavior are well known. Much of the information is summarized by Garrett (1956). Similar cultural studies on fungi associated with *M. hypopithys* would be necessary to give a clearer picture of their growth-forms and behavior, although Björkman's work has provided valuable information in regard to the situation in northern Europe.

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THE SOUTHEASTERN ADDER'S-TONGUE, *OPHIOGLOSSUM VULGATUM* VAR. *PYCNOSTICHUM,* FOUND FOR THE FIRST TIME IN MICHIGAN

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Over 120 species, distinct varieties or subspecies, and hybrids of pteridophytes are now known to occur in Michigan, and the number continues to increase, largely as a result of field explorations in the active pteridological research programs at the Cranbrook Institute of Science and The University of Michigan. Among the well developed families of ferns in the state is the Ophioglossaceae, the grapeferns and adder's-tongues. Of grapeferns, the genus *Botrychium,* we currently know of ten taxa in the state; of adder's-tongues, *Ophioglossum,* only one was recognized (Hagenah, 1966) until the discovery to be reported here.

What Wherry (1961) calls the "Widespread variety" of adder's-tongue in the eastern United States, namely *Ophioglossum vulgatum* L. var. *pseudopodum* (Blake) Farwell, is well known in Michigan from many localities in over 30 counties. It tends to grow in more or less open meadows, at edges of marshes, and along margins of wet ditches in somewhat acid soils, where, as Hagenah (op. cit.) has pointed out it "blends with the grasses and other vegetation, but after the first one is noticed search may reveal scores or even hundreds more." Many botanists and naturalists regard the adder's-tongue as a rare plant, but this is probably due largely to the fact that it is overlooked. The other variety of adder's-tongue in eastern United States is the so-called "Southeastern variety," *O. vulgatum* var. *pycnostichum* Fernald (1939). This taxon, which differs from the other in a number of technical characters, tends to grow in woods in neutral or calcareous, humus-rich soils, often along small streams and on flood plains. Var. *pycnostichum* is generally recognized to occur in the southeastern United States north to central New Jersey, southern Ohio and Indiana, and central Missouri (Wherry, op. cit.); it seems not to have previously been reported from the Great Lakes region.

Some authors (e.g., Clausen, 1938; Mohlenbrock, 1967) choose not to recognize different varieties in American adder's-tongues. Mohlenbrock (op.

TABLE I. Comparisons of two varieties of *Ophioglossum vulgatum*.

	Var. PYCNOSTICHUM	Var. PSEUDOPODUM
RANGE	1. Mainly s.e. U.S. to N.J., s. Ohio, Indiana, Illinois, Missouri. Only sporadic n. of border of Wisconsin glaciation.	1. Northern U.S. and Canada, mainly within area of Wisconsin glaciation.
HABITAT	2. Forested bottomlands, floodplain woods.	2. Pastures, meadows, marshes, grassy shores.
	3. Soil usually dark, humus-rich, pH neutral to alkaline.	3. Soil commonly light and sandy, pH usually acidic.
STERILE BLADE	4. Outline mostly ovate.	4. Outline mostly elliptic.
	5. Widest point (3-4 cm) in lower half.	5. Widest point (2-3 cm) in middle.
	*6. Base abruptly tapering.	6. Base gradually tapering.
	*7. Color dark green, shiny.	7. Color pale green, dull.
	*8. Texture firm.	8. Texture soft.
	9. Basal veins av. 9-11.	9. Basal veins av. 7-9.
BASAL SHEATH	10. Brown, leathery, persistent	10. Tan, membranous, ephemeral.
SPORANGIA	11. Transversely somewhat oblong and approximate.	11. Spherical and more remote.
SPORE DIAMETER	12. Av. 37-44 microns.	12. Av. 50-54 microns.

*Characters best seen in fresh material.

cit., p. 73) writes ". . . the difficulty in distinguishing var. *pycnostichum,* with a basal membranous sheath surrounding the bud, from var. *pseudopodum,* which lacks this sheath, has influenced this author in not maintaining these varieties." However, as shown in Table I, their differences are not confined to sheath development alone; indeed, in my study of the Michigan plants, I discovered a new character difference involving the spores which is more clear-cut than any previously reported. Fernald's original discussion, at the time he described var. *pycnostichum,* lists a number of distinctions between the two varieties. Well illustrated and documented, Fernald's treatment is not only very accurate and informative but also provides a fine example of his florid criticism, in this case of R. T. Clausen for his failure in discrimination. Speaking of Clausen's classification, Fernald deplored the fact that "proposed species and varieties are swept into one undifferentiated mass," and noted that "this easy and over-conservative viewpoint . . . will not be indorsed by those who intimately know the plants in the field. . ." As a result of my own observations of populations over a wide range of the eastern United States, I heartily support Fernald's view.

The Southeastern variety of adder's-tongue was discovered for the first time in Michigan in Seneca Township, Lenawee Co., on June 4, 1970, by the author in company with W. E. Hammitt. The locality (T8S, R2E, Sect.5) is a rich, more or less disturbed woodland bordering Vales Lake just south of Canandaigua and Whaley Roads on property owned by Mr. Jacob M. Bruggeman. Shallow intermittent ponds occur here, and in the rich, damp soil are found such other members of Ophioglossaceae as *Botrychium dissectum, B. multifidum,* and *B. virginianum.* Trees and shrubs which make up the woods here include *Acer rubrum, A. saccharum, Carpinus caroliniana, Celtis occidentalis, Gleditsia triacanthos, Juglans cinerea, Lindera benzoin, Morus rubra* (only juveniles seen), *Ostrya virginiana, Populus deltoides, Quercus bicolor, Viburnum acerifolium, V. dentatum, V. lentago,* and *V. prunifolium.* Persons familiar with the flora of this area will recognize woody species normally found in rich woods and swampy bottomlands, hardly the usual associates of the ordinary variety of adder's-tongue of Michigan. The damp richness of the soil conditions is evidenced also by the herbaceous flora, which contains such genera as *Arisaema, Aristolochia, Athyrium, Dryopteris, Erythronium, Hepatica, Hydrophyllum, Laportea, Onoclea, Phlox,* and *Sanguinaria.* The plants of *Ophioglossum* are scattered over approximately an acre of the woods, mostly only one or two specimens being found at a given spot. The total number of plants observed was between two and three dozen, some of them young and small. Those which were fully mature show a number of differences from the Michigan representatives of var. *pseudopodum,* and the sporangia in the fertile spike are elongated in a transverse direction rather than being approximately globular. It was obvious to us that these plants were distinct from the usual adder's-tongue of Michigan, and for this reason further studies were made during a re-visit to the locality on July 10. Voucher specimens (examples shown in Fig. 1) are my collection no. 70189 and will be deposited in The University of Michigan Herbarium and the Cranbrook Institute of Science.

Fig. 1. *Ophioglossum vulgatum* var. *pycnostichum.* Dried leaves from Lenawee Co., Michigan, *Wagner 70189.* 0.4X natural size. Sheath shown at tip of arrow.

Fig. 2. *Ophioglossum vulgatum* var. *pseudopodum.* Dried leaves from Washtenaw Co., Michigan, *Wagner 70398.* Same scale as Fig. 1.

In Figure 1 pressed leaves of var. *pycnostichum* are shown and in Figure 2, for contrast, a collection of leaves of var. *pseudopodum* (Washtenaw Co., Mich., Lyndon Twp., T1S, R3E, Sect. 19, *Wagner 70398).*

Following the discovery of the colony of var. *pycnostichum* in Lenawee County, collections were borrowed from various herbaria to review the differences between this and var. *pseudopodum.* These are summarized in Table I, which includes contrasts from Fernald (1950) and Wherry (1961). The two most interesting distinctions are those involving the so-called "sheath," and the sizes of the spores, the latter reported here for the first time. The sheath in these plants has been studied by Bruce W. McAlpin, of Duke University, who finds that both varieties possess it, but that the tissues which make up the sheath in var. *pycnostichum* are different from those in var. *pseudopodum,* being much thicker and more rigid in the former. While it persists in var. *pycnostichum,* the sheath seems to wither away in var. *pseudopodum,* and, when plants are dug up, becomes readily damaged and broken,

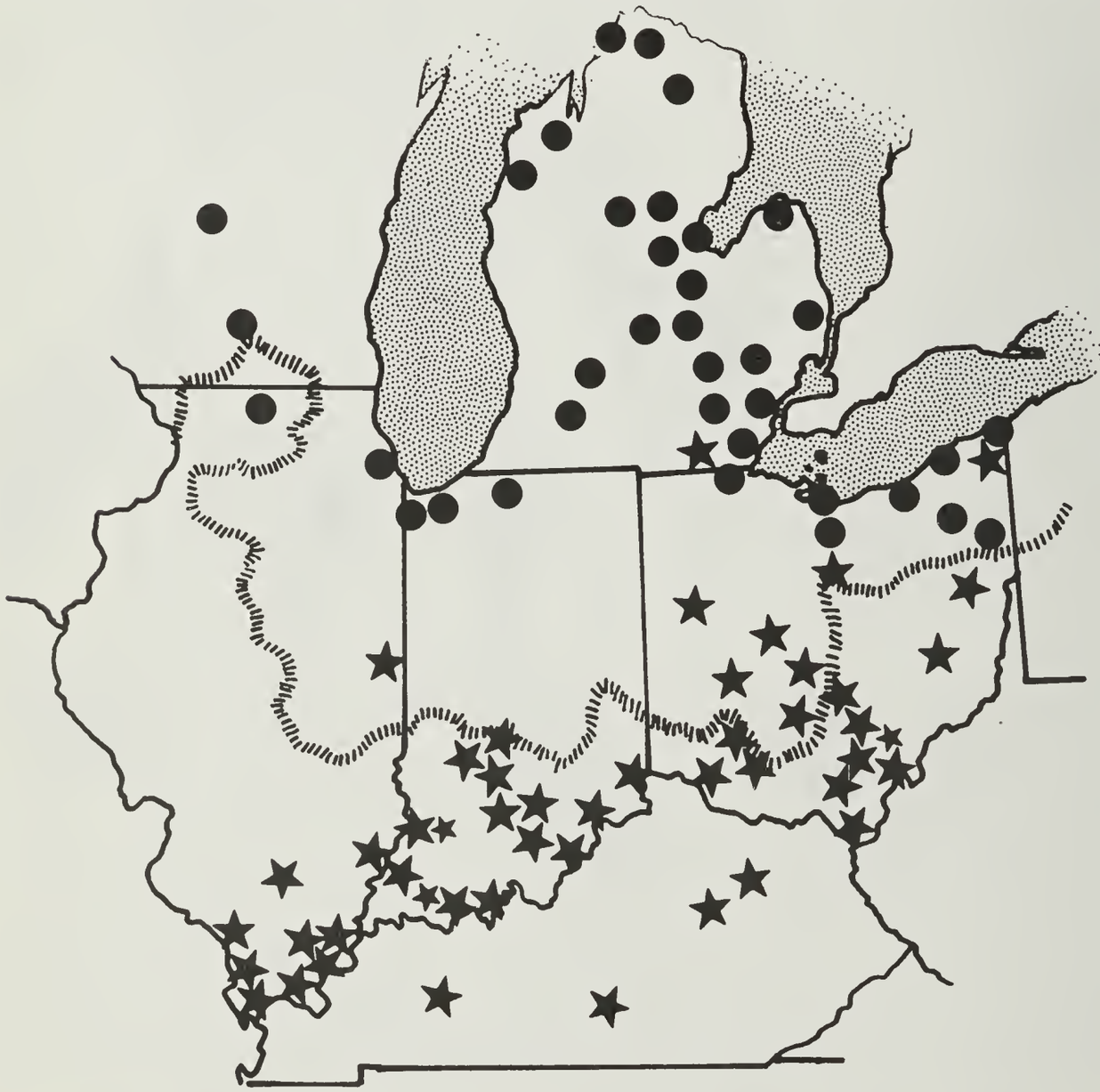

Fig. 3. Map of county distributions of *O. vulgatum* var. *pseudopodum* (dots) and var. *pycnostichum* (stars). Hatched line represents southern extent of Wisconsin glaciation. Based upon specimens in herbaria F, ILL, ILLS, IND, MICH, OS.

because of its membranous texture. In var. *pycnostichum* even when fronds are torn off the rhizome, the leathery sheath may remain attached, as shown on occasional herbarium specimens like that indicated by the arrow in Figure 1.

The spores of the two varieties proved to be strikingly different in size, the difference great enough that if one has spores from both taxa, it can be recognized instantly on microscope mounts. The following measurements were obtained from spores mounted in Hoyer's solution using an ocular micrometer. All were treated the same way, so that the measurements of the two varieties would be comparable. All specimens are from The University of Michigan Herbarium.

VAR. *PYCNOSTICHUM*

	Mean	Range	S. D.
MICHIGAN: Lenawee Co., *Wagner 70189*	37.6	33.6-43.2	2.6
MARYLAND: Montgomery Co., *Irving s.n.*	40.4	37.2-45.6	2.2
GEORGIA: Clarke Co., *Montgomery 419*	41.7	32.4-44.0	2.6
INDIANA: Jefferson Co., *Wagner 9271*	42.0	38.4-48.0	2.4
VIRGINIA: Craig Co., *Wagner 64056*	43.3	38.4-48.0	3.0

VAR. *PSEUDOPODUM*

	Mean	Range	S. D.
MICHIGAN: Midland Co., *Wagner 9096*	50.4	44.4-60.0	3.7
MASSACHUSETTS: Amherst, *H. P. Smith s.n.*	50.5	43.2-58.8	3.3
WISCONSIN: Douglas Co., *Conklin s.n.*	51.3	43.2-55.2	3.2
MICHIGAN: Saginaw Co., *F. W. Case s.n.*	53.6	49.2-56.4	1.9
WISCONSIN: Douglas Co., *Somerville s.n.*	53.8	48.0-61.2	3.5

As shown by these data, which were based upon samples of 25 spores from a single plant of each collection, the spores of var. *pseudopodum* average approximately 20 per cent again as large as those of var. *pycnostichum.* This may reflect differences in chromosome number, since cell sizes in plants are commonly correlated with levels of polyploidy. If these spore sizes do indeed reflect the chromosome conditions, then the northern adder's-tongue is probably a higher polyploid than the southeastern.

On the basis of specimens from several herbaria, the relative distributions of the two varieties in relation to the maximum southern extent of the Wisconsin glaciation were determined, and the results, shown in Figure 3, proved to show a correlation. For the two states for which the most complete collections were available, Ohio and Indiana, it is obvious that var. *pseudopodum* is north of the glacial border, and that most of the collections of var. *pycnostichum* are south of it. For Ohio and Indiana, out of 35 collections plotted, only 4 were more than 30 miles north of the line. Ashtabula County in extreme northeastern Ohio turned out to be the sole county in which both taxa have so far been encountered. The new station for var. *pycnostichum* in Michigan is the farthest from the boundary of Wisconsin glaciation known, being over twice the distance of any of the other northern collections. The Michigan locality is approximately 90 miles due north of the nearest other

locality of St. Marys, Auglaize Co., Ohio (April, 1898, *J. D. Limkins;* June, the same year, *A. Wetzstein;* herbarium of Ohio State University).

SUMMARY DISCUSSION

Ophioglossum vulgatum var. *pseudopodum* is the familiar adder's-tongue fern of Michigan and the Upper Great Lakes region. Another variety, the southeastern var. *pycnostichum,* is herein reported for the first time from Michigan, where it is evidently exceedingly rare and is known only in Lenawee County along the southern border of the state. Contrary to certain authors who do not differentiate the two varieties, I believe that their separation is strongly warranted on the basis of a number of average differences (summarized in Table 1). One of the differences, that involving the respective sizes of the spores, is reported here for the first time. A correlation can be demonstrated (Fig. 3) between the geographical distributions of the two taxa and the southern boundary of Wisconsin glaciation—var. *pycnostichum* to the south, var. *pseudopodum* to the north, with but few exceptions. In my experience, true var. *pseudopodum* is a strongly northern plant, and I have seen it only as far south as the mountains of Virginia and West Virginia, where it is rare. I therefore recommend that var. *pseudopodum* be called "Northeastern variety" rather than Wherry's (1961) appellation "Widespread variety."

ACKNOWLEDGMENTS

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SOME RARE OR UNUSUAL MICHIGAN FUNGI OF 1970

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The 1970 mushroom collecting season was one of the least productive experienced in Washtenaw County and environs in several years. There were only a few days when mushrooms were plentiful, but even then they were not as profuse as in previous years. Apparently, weather conditions were not right at the usual fruiting time for most fungi. Early Spring was too cold and dry. Summer was too dry for a prolonged period. Later the mycelia apparently could not benefit from the rains when they came. The Fall weather seemed to be very unfavorable for good production of fungi.

However, unusual conditions produce unusual fungi. In the pursuit of the elusive mushroom, persistence is rewarding. Frequent forays into the same locations during this "poor" collecting year proved to be a wise practice. During a "good" year, many fruit-bodies of normal size appear, but this year, single enormous specimens of many of the common species came forth as though an especially valiant effort for survival were being made.

One of the examples of this supposed effort was a giant morel, which was found by some linemen at the University of Michigan Botanical Gardens. This specimen, claimed to be 37 cm tall, was the only one in the immediate area under a large, dead elm, where numerous fruit-bodies usually grow. Luckily, this morel was too mature to eat so it is preserved in the University of Michigan Herbarium (*F. Hoseney 1536*).

Cantharellus cibarius, a choice species for food, and usually plentiful in rich woods, was also scarce, but a very large specimen was observed in an area which normally produces many of the mushrooms. This is a top-shaped, apricot-yellow, blunt-gilled mushroom, about 3 to 10 cm broad, in normal collecting seasons. This single specimen was about 17 cm across. Insect larvae had damaged it too badly for preservation.

Another fungus which always grows in clusters is *Clitocybe illudens.* It appeared in clusters of enormous individuals in spite of the dry weather. In fact, this type of "off" season seems to be very favorable for this *Clitocybe.*

In one of the few wet periods this summer, *Lepiota americana* also produced large fruiting bodies. This is an attractive, distinctive gill fungus which grows in closely packed fairy rings. This mushroom has been fruiting quite regularly in the vicinity of Ann Arbor the past few years.

Gyroporus castaneus is not difficult to find in mid-summer. A small, slender, orange-brown form with a yellow to orange margin appeared in substantial quantity in the E. S. George Reserve, in Livingston County. This bolete usually has a rusty red to vinaceous brown or chestnut colored pileus. Because of certain discrepancies in the color pattern of the pileus, this species is being studied further.

Several normally rare basidiomycetes were found in this "poor" year. A chance glance into a huge fallen hollow log lead to the discovery of a fruiting of the rare and arrestingly beautiful *Pluteus aurantiorugosus.* The bright orange-scarlet cap, and the light yellow-orange gills and stipe make this *Pluteus* breathtakingly beautiful when seen in contrast to the dark wood. The cap is 2-5 cm broad, convex, with a minutely striate margin. It grows on rotten stumps and logs of frondose trees, especially elm or ash. The cuticle of the pileus has round cells. This collection (*F. Hoseney 1740*), is preserved in the University of Michigan Herbarium.

On a foray to Winnewana Lake, in the Waterloo Recreation Area, W. W. Patrick and M. Gilliam found the rare *Boletus castanellus,* not previously known from Michigan (Fig. 1). Another rare and spectacular fungus, found this year by Duncan McCarthy in the grass near his grape arbor, is *Stropharia rugosoannulata.* This collection, (*R. L. Shaffer 6782*) is the first reported for the Lower Peninsula of Michigan. Mrs. Ingrid Bartelli collected it in the Upper Peninsula, in Marquette County, Sept., 1963. This species has a large fruiting body, saucer size to dinner plate size, with a chestnut brown pileus and a buff colored stipe with a thick annulus split radially and clapsing the pileus like a gem-stone. It seems to prefer cultivated ground such as a garden. It is truely a wonderful sight. Both collections are preserved in the University of Michigan Herbarium.

Fig. 1. *Boletus castanellus* from Waterloo Recreation Area (slightly reduced).

A previously described variant of *Leotia lubrica* (Mich. Bot. 8: 158-159. 1969) reappeared in the same location, late in November. A similar collection was obtained by W. W. Patrick in October from a nearby area. The reappearance of this fungus confirms the theory that it is not a freak, but a distinct hypogeous variant which warrants further study. This collection, (*F. Hoseney 1749*) was examined by Dr. K. A. Harrison and the following data recorded:

Leotia lubrica—a hypogeous variant

Gregarious to cespitose or concrescent at base, developing hypogeously.

Pileus convex, smooth or greatly wrinkled, lobed on margin and strongly incurved. Actual margin quite thin. Color citrine on surface and only slightly lighter on underside and to stipe. Surface very moist and lubricous, holding quantities of sand, most of which washes off readily. Cortex hyaline with olivaceous shade in center next to a thin hyaline layer under the paraphyses and asci.

Asci 190-230 X 10-12μ wide.

Paraphyses branched, same length as asci, filiform, septate, sometimes swollen next to septum, tips up to 3.5μ thick with slightly thickened walls, 3-8μ near tip of 30-50% of younger caps.

Ascospores uniseriate becoming biseriate in some, tending to be flexous, (20.0)22.0-26-26.5(30.0) X (5)6.0-6.6μ, 5-7-guttulate, curved, ends rounded, larger spores tending to be narrower than the shorter ones.

Ascocarps: Some compressed by hypogeous habit and stipe compressed and folded, up to 9 cm high, many 10 cm with 3 cm broad cap.

Stipe: Apex flattened, 1.7 cm on broader side X 0.6 cm where it extends to lobes, up to 10 cm long, hollow when expanded or when folded and then compressed to 3 or 4 mm thick, pale yellow-orange when young, varying to light yellow-orange later. Pallid towards base and then duller with a dingy appearance. Base blue-green where it arises from a round mass of sand, not a sclerotium or stroma. Surface with traces of green squamules near apex but these disintegrating and washing off. Cortex concolorous with the surface and forming a definite opaque gelatinous layer under the exterior gelatinous layer.

W. W. Patrick's collection of this *Leotia (2668)* was found Oct. 18, 1970, and is similar to *Hoseney 1170* and *1749* in color and habitat but the specimens are smaller, perhaps due to the drought of the past summer.

Collecting mushrooms is both fascinating and frustrating no matter if "good" or "poor" years come along. Every year is an unusual year for the mushroom collector!

THE MARSHALL BOG NEAR ITASCA PARK, MINNESOTA[1]

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INTRODUCTION

Sphagnum bogs and muskegs are not as widespread in the United States as in Canada, where those communities occupy about 500,000 square miles (MacFarlane, 1959). Nevertheless many authors have studied this particular ecosystem in the northern states of the United States, where one finds most of the bog systems. In Minnesota and adjacent states, Conway (1949), Heinselman (1963), Farnham (1965, 1966), Gates (1942), Reichle and Doyle (1965), among others, have described bogs of this region, while Leisman (1953) and Buell and Niering (1953) studied bogs of Itasca Park.

Fig. 1. A part of the Marshall bog, July 1966. (Photo by Fred Haavisto)

[1]This study was supported by a NSF Traineeship (Summer 1966).

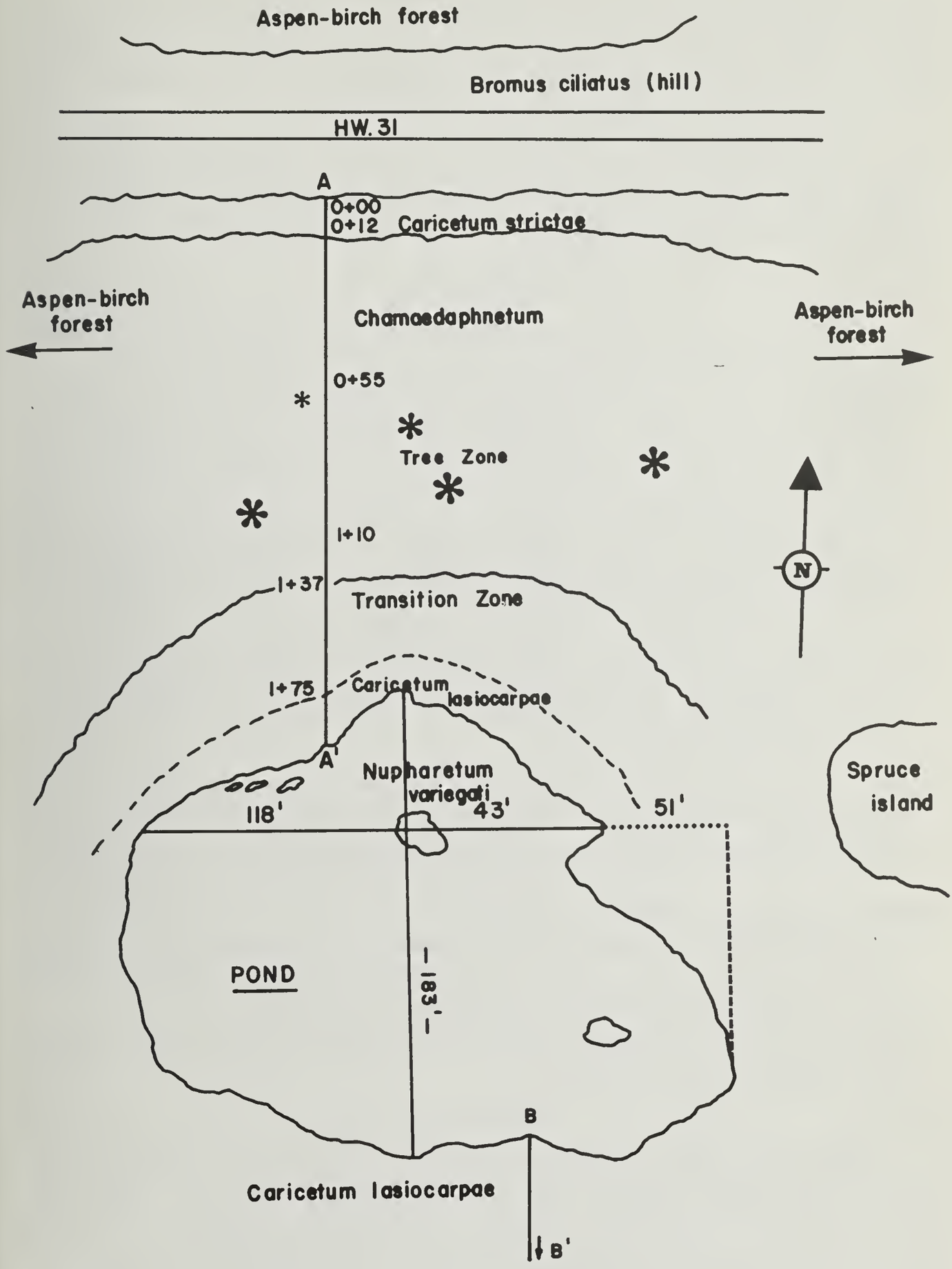

Fig. 2. General aspect of the Marshall bog in 1966.

However, there is still a lack of knowledge concerning the dynamics of this ecosystem. In fact only an intensive study of the synchorology of the biotope will allow future workers a better understanding of the rate of development of a bog. They must have a basic framework for comparison and the following ecological description fills a part of the gap.

The Marshall bog is a *Sphagnum* bog situated 7 miles west of Zerkel on the south side of Highway 31, in Clearwater County, Minnesota. It consists of a small pond surrounded by an invading bog vegetation. The bog lies in a basin and the upland vegetation is an aspen-birch forest (Fig. 1).

METHODS

The aim of the research being to establish a base against which to study the rate of the pond-filling process, I considered five aspects:

1. *Vegetation* from a phytosociological standpoint with the check-list of the species. The plots were made along two transects (A-A′ and B-B′) across the bog from the outer edge to the pond in a north-south direction (Fig. 2). The Narrow-Belt transect method was used (Oosting, 1956). Only transect A-A′ shall be dealt with, as both sides support similar vegetation. In each association along the line two 1 × 2 m quadrats were made for the abundance-sociability according to the Montpellier School (Braun-Blanquet, 1932). Nomenclature of vascular plants is according to Fernald (1950).
2. *Pond depth and dimensions.* The dimensions and depths of the pond along transect lines (Fig. 2) were obtained using a canoe and a 100-foot measuring tape. Measurements were taken every 10 feet along the transect with a graduated wooden pole.
3. *pH.* Hydrogen ion concentrations were determined from two water samples taken in each association and in the pond. The samples were kept in sterile plastic bottles and measurements were made the same day, immediately on return to the laboratory, with an electrode pH meter at room temperature.
4. *Peat temperature.* Data were collected on a hot sunny July day along the transect in each plant association, between 10:30 and 11:30 a.m., with a telethermometer at five levels: (1) Surface; (2) 6 inches depth (15 cm); (3) 1 foot (30 cm); (4) 2 feet (61 cm); (5) 3 feet (91 cm).
5. *Peat stratigraphy.* A Hiller peat borer was sunk to a depth of 2 m and the core was examined in the field.

RESULTS

The plant associations which compose the vegetation of the bog are as follows: *Caricetum strictae* in the outer edge; *Chamaedaphnetum calyculatae* in the middle; a sedge mat association *Caricetum lasiocarpae* on the pond shore; and, in the water, *Nupharetum variegati.* These vegetation zones, except *Nupharetum,* encircle the bog completely (Fig. 2). Between *Chamaedaphnetum* and *Caricetum lasiocarpae* there is a transition zone where scattered plants of *Chamaedaphne calyculata* occur.

In the *Carex stricta* association, the water level is very high in the spring but goes down rapidly in the summer. The moss layer of this association is the least rich in species, which increase in number and abundance towards the pool. *Carex stricta, Betula pumila,* and *Chamaedaphne calyculata* are the dominants with *Eriophorum spissum, Salix pedicellaris,* and *Alnus rugosa* associated with them.

Chamaedaphnetum, the association occupying the largest area (Fig. 2), changes physiognomically along the transect line and leatherleaf becomes less dense and less high towards the free water, allowing the recognition of the transition zone. In this association, *Chamaedaphne, Betula pumila, Salix pedicellaris,* and *Andromeda glaucophylla* are dominant, associated with *Smilacina trifolia* and *Vaccinium oxycoccos.*

Three kinds of pine grow with black spruce and tamarack in this plant grouping: *Pinus strobus* (white pine), *Pinus resinosa* (red pine), and *Pinus banksiana* (jack pine). The tallest pine specimen, 7 m high, was a jack pine 26 years of age (as determined from increment boring) with a D.B.H. of 14 cm. However, the oldest was a red pine, 31 years old, only 5 m high and a D.B.H. of 9 cm. As expected, tamaracks are the oldest conifers since they are the first to invade *Sphagnum* bogs. The two highest were 8 m with a D.B.H. of 14 and 15 cm respectively and 43 and 45 years old. Two black spruce out of three samples were 41 years old. One might note that white pine is doing poorly compared to red pine judged by appearance and growth rate.

It is in the transition zone (Fig. 2) that the flora offers the greatest variety (Table 1) *Menyanthes trifoliata, Potentilla palustris, Equisetum fluviatile,* and *Scheuchzeria palustris* are among those which reveal the minerotrophic conditions that still prevail in this part of the bog.

The *Carex lasiocarpa* association near the pond, with its high water table, is characterized by the abundance of *Carex,* with *C. lasiocarpa, C. limosa,* and *C. rostrata. Epilobium palustre, Typha latifolia,* and *Dulichium arundinaceum* are among the species not found elsewhere.

I must mention here an interesting point which has no apparent cause to my knowledge: pitcher-plant (*Sarracenia purpurea*), a typical *Sphagnum* bog plant, is absent from the Marshall bog.

Along the transect line several samples of mosses were gathered. Some of them showed a correlation with the gradient, others with the topography. For instance, *Sphagnum fuscum* is found on top of hummocks and *S. papillosum* in the hollows, while *S. capillaceum* usually grows in the middle of hummocks. Along the gradient from the outer edge towards the pond one finds *Sphagnum subsecundum, Polytrichum commune, Climacium dendroides,* and *Bryum* sp.; then *Sphagnum dusenii, Polytrichum strictum,* and finally many other species of *Sphagnum* including *S. obtusum, S. magellanicum, S. centrale,* and *S. recurvum.*

On the east side of the bog in the *Chamaedaphne* zone, there is a small black spruce island and the understory shows some characteristic species of the colonizing flora, such as *Ledum groenlandicum* and *Carex trisperma,* not found elsewhere. The transect B-B′ (Fig. 2) shows the same evidences of

TABLE 1. Indices of cover-abundance and sociability in each association along transect A-A′.

Association	Caricetum strictae		Chamaedaphnetum calyculatae		Transition zone		Caricetum lasiocarpae	
Plots	1	2	1	2	1	2	1	2
Carex stricta	4.3	4.3						
Betula pumila	3.3	2.3	4.3	2.3	2.2	+.1		
Chamaedaphne calyculata		+.1	5.4	5.4	2.3	3.3		
Salix pedicellaris			+.1	+.1				
Andromeda glaucophylla				+.1	1.2	+.1		
Vaccinium oxycoccos				1.2	1.2	1.3		
Smilacina trifolia			1.2	+.2	1.3			
Menyanthes trifoliata					1.2	+.1		
Equisetum fluviatile					+.1	+.2		
Potentilla palustris					+.2	2.2		
Eriophorum spissum		+.1		+.1				
Carex canescens						1.2		
Drosera rotundifolia					+.1			
Scheuchzeria palustris					+.1	+.1	1.3	1.2
Carex lasiocarpa							3.4	3.4
Carex rostrata							1.2	1.2
Carex limosa							+.1	+.2
Vaccinium macrocarpon						+.2		1.3
Eriophorum gracile							+.1	
Carex interior								+.1
Hypericum virginicum								+.1
Dulichium arundinaceum							+.1	
Epilobium palustre							+.1	
Sphagnum spp.		2.4	2.4	4.5	5.5	5.5	3.5	2.3
Other mosses		1.3	1.3			+.2		

succession. Nevertheless, the *Caricetum strictae* contains some species not observed on the north side: *Salix bebbiana, S. gracilis,* and *Populus balsamifera.*

Except for the northern section where Highway 31 is located, the bog is surrounded by an aspen-birch stand dominated by *Populus tremuloides* and *Betula papyrifera.* A few oaks, *Quercus borealis* and *Q. macrocarpa,* can also be found with *Tilia americana.* The shrub layer is equally composed of aspen and birch. *Amelanchier humilis, Viburnum pubescens,* and *Alnus rugosa* grow at the margin of the stand.

Aster macrophylla, Thalictrum dioicum, Lathyrus japonicus, Pteridium aquilinum, Rhus radicans, Aralia nudicaulis, and *Uvularia grandiflora* are the most conspicuous species of the herb layer in mid-July.

CHECK-LIST OF THE BOG FLORA

NAMES	LOCATION
Trees and shrubs:	
Pinus resinosa Ait.	*Chamaedaphnetum*
Pinus strobus L.	*Chamaedaphnetum*
Pinus banksiana Lamb.	*Chamaedaphnetum*
Larix laricina (Du Roi) K. Koch	*Chamaedaphnetum*
Picea mariana (Mill.) B.S.P.	*Chamaedaphnetum*
Populus balsamifera L.	*Caricetum strictae*
Betula pumila var. *glandulifera* Regel	General
Salix pedicellaris var. *hypoglauca* Fern.	*Chamaedaphnetum*
S. bebbiana Sarg.	*Caricetum strictae*
S. gracilis Anderss.	*Caricetum strictae*
Chamaedaphne calyculata (L.) Moench	General
Andromeda glaucophylla Link	General
Ledum groenlandicum Oeder	Black spruce island
Vaccinium oxycoccos L.	*Chamaedaphnetum* and transition
V. macrocarpon Ait.	Transition and *Caricetum lasiocarpae*
Herbs:	
Carex stricta Lam.	*Caricetum strictae*
C. lasiocarpa Ehrh.	*Caricetum lasiocarpae*
C. rostrata Stokes	*Caricetum lasiocarpae*
C. limosa L.	*Caricetum lasiocarpae*
C. interior Bailey	*Caricetum lasiocarpae*
C. canescens L.	Transition zone
Eriophorum spissum Fern.	*Chamaedaphnetum* and transition
E. gracile W.D.J. Koch	*Caricetum lasiocarpae*
Drosera rotundifolia L.	*Chamaedaphnetum* and transition
Smilacina trifolia (L.) Desf.	*Chamaedaphnetum* and transition
Menyanthes trifoliata L.	Transition zone
Scheuchzeria palustris L.	Transition and *Caricetum lasiocarpae*
Potentilla palustris (L.) Scop.	Transition and *Caricetum lasiocarpae*
Lysimachia thyrsiflora L.	Transition and *Caricetum lasiocarpae*
Equisetum fluviatile L.	Transition and *Caricetum lasiocarpae*
Hypericum virginicum L.	*Caricetum lasiocarpae*
Typha latifolia L.	*Caricetum lasiocarpae*
Utricularia intermedia Hayne	*Caricetum lasiocarpae*
Epilobium palustre L.	*Caricetum lasiocarpae*
Dulichium arundinaceum (L.) Britt.	*Caricetum lasiocarpae*
Eleocharis calva Torr.	*Caricetum lasiocarpae*
Glyceria borealis (Nash) Batch.	*Caricetum lasiocarpae*
Nuphar variegatum Engelm.	Open Water
Potamogeton pulcher Tuckerm.	Open Water
Sphagnum mosses:	
Sphagnum magellanicum Brid.	General
S. capillaceum (Weiss) Schrank	General

NAMES	LOCATION
S. fuscum (Schimp.) Klinggr.	General
S. dusenii Russ.	*Chamaedaphnetum*
S. centrale C. Jens.	*Chamaedaphnetum*
S. squarrosum Sw.	General
S. obtusum Warnst.	*Caricetum lasiocarpae*
S. recurvum P.-Beauv.	Transition zone
S. subsecundum Nees	Black spruce island
Other mosses:	
Hypnum lindbergii Mitt	*Caricetum lasiocarpae*
Aulacomnium palustre (Hedw.) Schwaegr.	General
Polytrichum strictum Brid.	General
P. commune Hedw.	*Caricetum strictae*
Helodium blandowii (Web. & Mohr) Warnst	*Caricetum strictae*
Climatium dendroides (Hedw.) Web. & Mohr	*Caricetum strictae*
Bryum sp.	*Caricetum strictae*
Lichens:	
Cladonia chlorophaea (Flk.) Spreng.	*Sphagnetum*
Peltigera polydactyla (Neck.) Hoffm.	Transition zone

The flora of Marshall bog is then composed of 39 tracheophytes, 16 bryophytes including 9 species of *Sphagnum,* and 2 species of lichen, for a total of 57 species. The above list includes all species collected in the bog, not only those along the transects.

The pond. The width of the free water in the north-south direction was 183 feet in 1966. The length was 161 feet in the northern section and 225 feet in the southern part (Fig. 2). There were five floating islands in the pool and the largest crossed the transect. It was 9 feet long and its vegetation composed mostly of *Eleocharis calva,* with *Dulichium arundinaceum, Carex retrorsa,* and a few specimens of *Glyceria borealis.* This floating mat cannot yet support the weight of a man.

As can be seen from Table 2, the water is quite deep close to the loose floating *Carex lasiocarpa* association. There is a difference of 26 inches between 0 + 00 and 0 + 05. The same situation occurs on the other side of the pool where one finds a difference of 19 inches at only 3 feet from the *Carex* mat.

The pond bottom shows a certain irregularity in depth but in general it varies between 3 and 4 feet. The maximum depth is at 1 + 20 (45 feet south of the island), where the depth is 6 feet. Only one other reading exceeds 5 feet (68 inches).

Vegetation of open water. The floating vegetation is here a good example of a pond-filling bog formation since its flora represents the early first stage of the

TABLE 2. Depth of the pond at different distance from the shore.

Distance (feet)	Depth (inches)	Location
0 + 00	20	End of the floating *Carex* mat
0 + 05	46	Open water
0 + 20	41	Open water
0 + 30	45	Open water
0 + 40	23	Open water
0 + 50	33	Open water
0 + 60	40	Open water
0 + 70	--	Floating island
0 + 73	--	End of the island
0 + 80	52	Open water
0 + 90	54	Open water
0 + 00	68	Open water
0 + 10	52	Open water
0 + 20	72	Open water
0 + 30	42	Open water
0 + 40	55	Open water
0 + 50	45	Open water
0 + 60	44	Open water
0 + 70	36	Open water
0 + 80	33	Open water
0 + 83	14	Edge of *Carex* mat

pioneer invasion forming the *Nupharetum variegati* association with *Nuphar variegatum* and *Potamogeton pulcher* as co-dominant (Dansereau & Segadas-Vianna, 1952). The latter replaces in this community *Potamogeton natans* usually found in the association elsewhere, as for example in eastern Canada.

pH. The data in Table 3 reflect the expected situation in a bog of this type. The presence of *Carex stricta* in the outer edge reveals the existence of rich nutrients and water movement. Because of the above mentioned two factors, it is evident that the pH here must be higher.

TABLE 3. Hydrogen ion concentration in the Marshall bog (averages of two samples from each location).

Associations	pH
1. *Caricetum strictae*	6.45
2. *Chamaedaphnetum calyculatae*	5.80
3. Transition zone	4.60
4. *Caricetum lasiocarpae*	5.85
5. Water, one foot from the mat	6.40
6. In the pond	6.60

The lowest pH values are encountered in the transition zone, whereas they increase again towards the pond. It is interesting to note the striking difference in the hydrogen ion concentration (5.9 vs. 6.4) at the edge of the sedge mat and at only 1 foot outward from it.

Bog temperature. The tree zone of the *Chamaedaphne* association is the coldest part of the bog while *Caricetum lasiocarpae* near the pond, with its sparse vegetation, is the warmest (Fig. 3). The constant decrease of temperature near the surface, from the outer edge towards the transition zone, is the result of the increasing density of the vegetation intercepting more and more of the sun's heat. This phenomenon is well illustrated by surface water

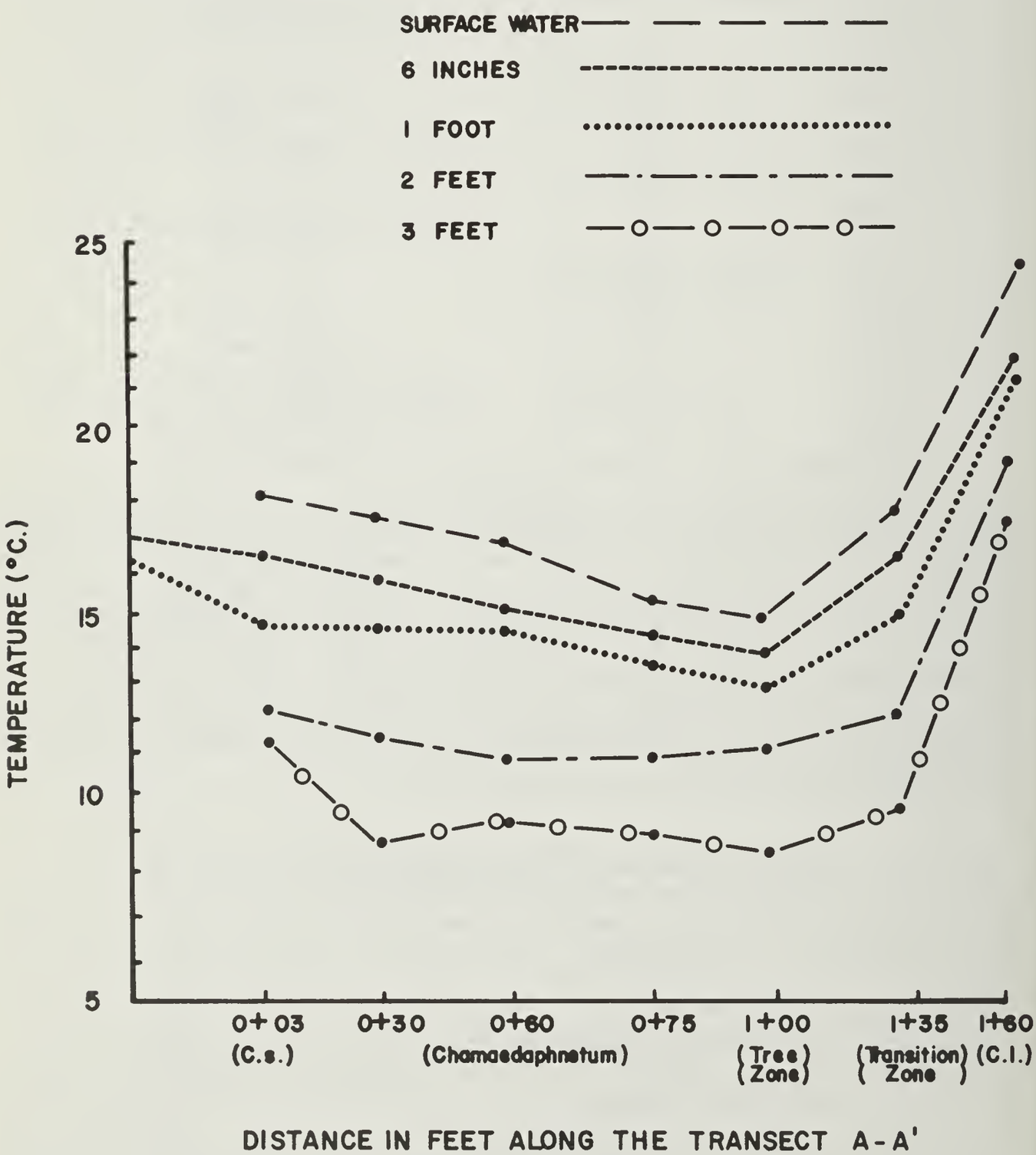

Fig. 3. Temperature at different depths in the peat.

temperature which was at 14.5°C under a dense growth of *Chamaedaphne* and as high as 24°C in the *Caricetum lasiocarpae.*

The decrease of temperature with depth is about .5°C to 1°C every 15 cm. At 1 m depth minimum temperature during mid-summer in the Marshall bog is around 8°C. At this level, amplitude is almost nonexistent (Geiger, 1957; Molga, 1962). At 61 cm (2 feet) depth, temperature lies around 10°C.

The peat boring shows that the water level has risen considerably and that the vertical succession follows the same pattern as the horizontal succession.

TABLE 4. Peat stratigraphy of the Marshall bog.

Depth	Kind of peat
Surface	*Sphagnum capillaceum, Polytrichum strictum*
0 - 40 cm	*Sphagnum capillaceum, Polytrichum strictum*
40 - 60 cm	Floating *Sphagnum* mat
60 cm - 1 m	Gap. May be very soft sedge peat
1 m - 120 cm	Moss peat
120 - 170 cm	Sedge peat
170 - 220 cm	Lacustrine deposits, like guttja

DISCUSSION

The Marshall bog is a good example of a filled-lake *Sphagnum* bog formation. The different zonations of this vegetation correspond quite well with the well-known description of Dachnowski-Stokes (1912). These zonations represent the two stages of bog succession: the pioneer stage composed here of the *Nupharetum variegati* and the *Caricetum lasiocarpae* association (Dansereau & Segadas-Vianna, 1952).

In the Marshall bog, however, instead of the *Laricetum laricinae* association which usually follows the *Chamaedaphnetum,* we encounter a large number of pines. Nevertheless I do not believe that the next stage will be a pine association and the presence of young tamaracks leads me to expect a normal *Laricetum* succession within a few years.

The flora of this autogenous sere (Dansereau, 1957), reveals minerotrophic conditions in the greatest part of the bog. In fact, the abundance of such species as *Equisetum fluviatile, Menyanthes trifoliata,* and *Potentilla palustris* indicates that the mineral soil water still has an influence on the vegetation (Sjörs, 1961). As long as seepage influences conditions, pH will be above 4 (Joyal, 1970). Nevertheless, contrary to Conway's statement (Conway, 1949), a pH over 5 does not inhibit growth of *Chamaedaphne* (Table 3).

The dense part of the *Chamaedaphnetum* advances towards ombrotrophic conditions; the rate at which this occurs could be determined only by further research of the same kind in later years. *Ledum groenlandicum* and perhaps *Kalmia polifolia* will soon invade the bog and will consolidate the ecosystem.

SUMMARY

The Marshall bog is a pond-filled *Sphagnum* bog with a small pond at the center surrounded by a typical minerotrophic vegetation evolving towards ombrotrophic conditions. *Carex stricta, Chamaedaphne calyculata,* and *Carex lasiocarpa* associations are present. The oldest trees invading this ecosystem (tamaracks) are 43 years old. Black spruce and three species of pine are also present. pH varies between 4.6 in the mat and 6.6 in the middle of the pond. Temperature at a 1 m depth in *Sphagnum* peat ranges from 8°C to 11°C in July depending on the plant association. Peat depth in the center of the consolidated mat is 220 cm. A total of 16 bryophytes and 39 tracheophytes have been identified.

ACKNOWLEDGMENTS

The author is indebted to Professor Hugo Sjörs of Uppsala University, Sweden, for his guidance during the research and for the identification of the mosses. He is also thankful to Mr. Fred Haavisto from the Department of Fisheries and Forestry of Canada for his technical assistance in the field.

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Nature education feature --

AN INTRODUCTION TO THE COLLECTION AND STUDY OF HIGHER FUNGI[1]

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Initially, the beauty of the higher fungi attracted my attention, but as a biologist I was curious to learn how to identify them. In order to pursue the study of fungi, it is necessary first to make a good collection, keeping several procedures in mind.

COLLECTING

The proper equipment for collecting fungi includes a large market basket without a cover and one or two smaller containers which are carried in the basket for small fungi. In addition, one needs a hunting knife or small garden trowel, a roll of waxed paper, pencil, and pad. Dress for a field trip should be appropriate to the season. Also, insect repellent is essential in the summer.

Care must be used when collecting fungi since some species of *Collybia* and *Amanita* have underground parts necessary for identification. When possible, collect specimens in all stages of development. Many times what appears to be the same species will be scattered over a large area. In this case, one should collect several fruiting bodies but wrap each one separately in order to avoid mixed collections.

The carpophores (fruiting bodies) should be wrapped in waxed paper to avoid loss of moisture. This is done by laying the specimens on a sheet of waxed paper, rolling it up, and twisting each end. Small, delicate specimens may be placed in covered containers for transport. Larger specimens should be placed in the bottom of the basket.

A small piece of paper about 2″ × 4″ is used to make a field label for each collection. Information on each of the labels includes: serial number in the upper left corner, name of fungus or group to which it belongs, type of habitat, place and date collected, and collector's name. The name of the person who identifies the specimen may be added later. A copy of the field label accompanies each collection stored in a herbarium.

A field notebook is kept, with collections listed by number, name of fungus or group, place, and date collected. That is important for future reference.

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[1]Adapted from a portion of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Biology at Eastern Michigan University, 1970. The aid and encouragement of Dr. A. H. Smith, of The University of Michigan, in introducing me to the methods here described is gratefully acknowledged.

An essential procedure for the study of all Hymenomycetes (mushrooms and their allies) is to obtain the spore print. To get a spore print, one may take a fairly young specimen, remove the stipe, and place the cap on a piece of white paper, gills down. This may be done in the field, in which case the paper must be wrapped around the cap before placing it in the basket. If one desires to make the spore print upon returning from the field, one follows the same procedure, covering the cap with a cup or small bowl to prevent air currents from disturbing the falling spores. One should obtain a print in about one-half hour. A wilting cap may either deposit no spores, or those which it does deposit may not necessarily be typical as to size range and development for the species being studied. It is frustrating to get so few good spore prints, but when one considers that a specimen must be gathered at exactly the right stage for spore discharge, it is not surprising. It is worth noting that a fleshy form must be fairly young to yield a spore print, but, on the contrary, tough basidiocarps may deposit spores for a day or a week. It is best to collect puffballs which have dried out since the gleba will then be developed. One does not obtain a spore print from a puffball because spores are not discharged from the basidia.

Smith (1949) recommends that collections of fresh fungi be studied in the following order:

1. All members of the *Coprinus* group because of their habit of deliquescing shortly after spore discharge.
2. Any other fragile species such as Mycenas.
3. All species of Boleti since they are soft and subject to damage by larvae.
4. All viscid fungi.
5. All other fleshy forms.
6. Tough leathery or woody species such as many polypores.

MACROSCOPIC CHARACTERS

An outline is used in describing the macroscopic characters of carpophores in order to systematize the process of recording data. It includes the following features: stipe—size, surface, and shape; presence of annulus or volva; gills—spacing, attachment, width, color, details of the edge, and number of lamellulae; pileus—size, shape, surface, color; odor; latex; and color of spore deposit. It is helpful to note any striking characteristic which might aid the field identification in the future. The outline naturally can be modified to include tubes or pores when describing other than gilled forms. I record descriptions on 4″ × 6″ cards on which the collection number is placed in the upper left-hand corner. For this part of my work, I rely heavily on Dr. Smith's book, *Mushrooms in their Natural Habitats* (Sawyer's, Inc., Portland, Ore., 1949), as well as *A Glossary of Mycology* by Snell and Dick (Harvard University Press, Cambridge, Mass., 1957). For identification of colors, the *Methuen Handbook of Colour* by Kornerup and Wanscher (Methuen & Co. Ltd., London, 1967) is useful in most cases, but lacks the brown shades so necessary in describing many species of fungi.

PRESERVATION OF SPECIMENS

After collections have been made as described in the preceding manner, they are dried to preserve them for further study. I use a dryer with a frame 48″ high, having fine screen shelves, 13″ X 25″, of 1/8″ mesh. For a source of steady heat, I use one or two hot plates depending on the outdoor temperature and the size and quantity of specimens being dried. The frame is surrounded on all four sides by a piece of fireproofed canvas held in place by clips. The dryer is housed in a small building about 7′ X 3½′ which proved to be ideal since the heat and odors would have been unpleasant if drying had been done close to living quarters during the summer.

The field label should be kept near each collection while being dried. Once specimens are put on the dryer, they must be allowed to dry completely before removal. Intermittent heating results in specimens which are poor for study due to discoloration and possible collapse of the tissue. I usually leave mine on the dryer for about 24 hours, but the size and thickness of tissue determine the length of drying time. Very small, fragile species like Mycenas dry in a few hours.

Properly dried specimens are brittle but will become pliant and easier to handle if left overnight in a damp place. Collections should be stored permanently in cardboard boxes of appropriate size. Insects can be killed by adding a small amount of paradichlorobenzene crystals to each box twice a year. However, after fumigation for about two weeks with paradichlorobenzene, any remaining crystals may be removed and naphthalene crystals added instead. Naphthalene acts as an insect repellent and lasts longer than paradichlorobenzene.

METHODS FOR MICROSCOPIC STUDY

When the collecting season comes to an end in the fall, one can start the study of the microscopic characters in preparation for the final identification of the material. (Identification of the collections is made by use of keys to families, genera, and species.)

The procedure for microscopic study is as follows. First, examine the spores from each collection if a print is available. In the absence of a spore print, spores associated with a section of the gill or a piece of gill can be studied. The iodine test is useful when studying spores which are white to yellow in deposit. Spores are categorized in the following manner based on their reaction to iodine solution: amyloid, if spores take on a grey to violet color; dextrinoid, if red-brown to purple brown color results; non-amyloid, if the spores remain uncolored or merely yellow. As a mounting medium, Melzer's reagent is used. The formula is potassium iodide 1.5 grams, iodine 0.5 grams, distilled water 20.0 grams and chloralhydrate 20.0 grams. The material to be studied is mounted directly in the mounting medium. Results may usually be observed within five minutes.

Next, the size range in microns within which the majority of spores fall is recorded. A microscope having an oil immersion lens and a cali-

brated eyepiece micrometer is necessary for measuring spore size. Even more significant than size is the structure of the basidiospore. Among the important features to note are shape, wall surface and thickness, presence of germ pore, and whether the spore is truncate at the apex or apiculate at the base. One can also observe the basidia in a tissue mount to determine the number of spores per basidium since they may be constantly two- or four-spored or vary from one to four. The latter condition may lead to variation in both size and shape of spores.

Besides studying the spores and basidia of each species, examine the hymenium for the presence of cystidia. These are sterile cells scattered irregularly among the basidia. The presence or absence of cystidia and, if present, their size and shape are important in taxonomy. Pleurocystidia are located on the faces of the gill and cheilocystidia along the gill edges. They usually but not always project beyond the tips of the other cells and are fairly apparent because of the different morphology. Cheilocystidia may or may not vary morphologically from pleurocystidia. Usually the pleurocystidia in a single species are one type, but often there are two types of cheilocystidia.

To study the hymenium, free-hand sections of the hymenophore are made. For the study of dried material, cut a wedge-shaped section out of the pileus, apply to it a few drops of 95% ethanol to drive out the air, and soak it in tap water for a few minutes until it softens. Then remove it and dry off the excess moisture. Next, fold the tissue using the radius of the cap as the long axis. I use elder pith split lengthwise to hold the tissue firmly as I cut off thin sections with a straight razor. One should make the first cut at a point midway between the margin and center of the cap. Proceed to make sections through pith and tissue, transferring the thinnest to a slide on which a drop of 2.5% KOH has been placed. After removing bits of pith, cover with a #1 coverslip and observe under an oil immersion lens. KOH is the best reagent for reviving cystidia. If mounting sections in Melzer's reagent or KOH, one should always wipe the razor on a towel between sectioning to avoid contamination of one reagent with the other.

It is often difficult to section through gills to show the cheilocystidia, so one may prefer to take a piece of gill complete with margin, revive it in KOH, and add a coverslip. First, observe for cystidia as it is. One can usually see the cheilocystidia this way if they are not diminutive and buried. Also, the pleurocystidia will show up in contrast to the other usually smaller cells on the face of the gill. Later, crush the gill by placing the slide covered with a towel between thumb and forefinger and carefully apply pressure. More reagent may be added as needed. After the section has been crushed, the size and shape of the cystidia become more obvious as a result of isolating the cells.

In the case of the Boletaceae, study the spores and also the surface of the pileus since the pileus cuticle shows features useful in taxonomy. Add a few drops of ethanol to the pileus surface, shave off a thin section of the cuticle, and mount it in KOH in order to study the arrangement of the hyphae and details of the cells.

The method for studying puffballs or Gasteromycetes is as follows. For

field study, observe the following characters: the markings on the wall of the spore case or peridium; the way it opens to release its spores; and the macroscopic characters of the gleba (Smith, *Puffballs and Their Allies in Michigan,* Univ. of Mich. Press, 1951). For microscopic examination of spores in Melzer's reagent, place a bit of the gleba directly in it. However, before reviving gleba in KOH, one must first moisten it with ethanol and then transfer a bit of that gleba to KOH.

When studying members of the family Polyporaceae, one can merely match each specimen with known material in a herbarium, using a hand lens for more detailed examination. This is possible since polypores have woody basidiocarps which do not change so much in drying as do the gilled forms.

When working on the Ascomycetes, section the hymenium in the same manner as outlined above for the Agaricales and note the size and shape of the asci and number of spores per ascus in addition to studying the spores themselves.

All of the above methods are basic to the routine study of higher fungi. However, when using a key, one is often called upon to section other parts of the fruiting body to ascertain other characters upon which the key was based. The basic technique for the study of all parts is the same as for the hymenium.

Using the techniques described above, teachers and students can prepare specimens of fungi, together with notes, which will be of suitable quality for identification using the vast literature of mycology. And they will also be adequate for study by a specialist, when it becomes necessary to consult one. Collecting fungi can be as interesting, satisfying, and profitable as collecting any other group of plants for a hobby or for more serious study.

Review

THE BOLETES OF MICHIGAN. By Alexander H. Smith and Harry D. Thiers. University of Michigan Press, Ann Arbor. 1971. 428 + [14] pp. + 157 pl. $20.00.

Mycologists and mycophagists need only be advised that this volume is available, for they will recognize the value of owning a copy. Most of the 213 species of Boletaceae included and fully described are already known from Michigan; the others are to be expected. For some of the species, county records are cited. Numerous new taxa are described. In addition to technical keys, there are handy field keys to species or groups (these in the chapter on edibility). The plates reproduce well 180 photographs of Dr. Smith's usual high quality, which readers of this journal know well. Many of them identify by collection number the specimen shown, although these are not always cited in the text. In addition, 14 unnumbered pages include 133 figures of microscopic details. An introduction explains structure and terminology, procedures for study, habitat relationships, and evolutionary trends in the family. The work is dedicated to the late Victor C. Potter (1920-1964), enthusiastic amateur mycologist of Ithaca, Gratiot Co., of whom a portrait serves as frontispiece.

–E. G. V.

CYRUS H. McCORMICK EXPERIMENTAL FOREST

On January 4, 1971, the United States Forest Service announced the official establishment of the Cyrus H. McCormick Experimental Forest in Baraga and Marquette counties, Michigan. This tract, about 12 miles north of Champion and 32 miles west of Marquette, was willed to the Forest Service as a research area by the late Gordon McCormick, grandson of Cyrus Hall McCormick, the farm-implement inventor. The 17,164 acres (including a 40-acre inholding by the State of Michigan) contain about 20 lakes and are on the divide between Lakes Superior and Michigan. The Yellow Dog River, the Dead River, and two branches of the Huron River originate in the tract and flow into Lake Superior. In the southwest corner of the Forest, Baraga Creek joins the Peshekee River, which flows south to Lake Michigan.

About two-thirds of the tract is occupied by northern hardwood forest types which include some pine. Lowland forest types such as spruce-fir, white cedar, and lowland hardwood are found on 18% of the tract. There are scattered stands of old growth hardwoods, hemlock, and white pine. Elevations range from about 1500 to 1900 feet above sea level (or 900 to 1300 feet above Lake Superior). Rugged rock bluffs and hills sometimes exhibit vertical drops of over 100 feet. More than 100 miles of foot trails occur throughout the area. The East Falls on the Yellow Dog River and North Falls on a branch of that river are special scenic attractions.

Research on the Forest will maintain and take full advantage of its wilderness-like condition. It is especially suitable for primitive or pioneer forest recreation, accompanied by a program of research dealing with man's use of back-country environments—an opportunity which is strengthened by a substantial roadless buffer zone surrounding most of the Forest. The compactness of the Forest boundaries, the lack of inholdings, and the lack of access to the perimeter are factors which will help to control use. Research activities will be the responsibility of the North Central Forest Experiment Station, working cooperatively with the Michigan Department of Natural Resources and universities. Contemplated research includes sources of user satisfaction and dissatisfaction and impact of remote-area experiences on people of different ages and backgrounds, as well as ecological processes on a wide range of site conditions. There is good potential for studies on the direction and magnitude of ecosystem changes and the ecological impact of low density recreation; long-term observations are possible on wildlife habitat, insects and disease, and other problems related to northern hardwoods.

The McCormick Experimental Forest is an addition to the Ottawa National Forest, which is responsible for protection and maintenance of the area. Regulations established in February, 1970, for protection of this tract include prohibition of overnight camping and campfires, as well as closure to all forms of motorized wheeled and tracked vehicles and mechanical transport, horses or stock of any kind, and all types of motorized equipment.

Program Notes

May 2: Michigan Botanical Club State Meeting at Walden Woods Conference Center, Hartland, Michigan. Ham dinner, field trips, program. Make your reservations!

May 28-31: Michigan Botanical Club spring campout, Yankee Springs Recreation Area, Barry County. A full program of field trips and other events is planned. Save the dates and get your reservations in when final information is distributed.

WELCOME TO A NEW CHAPTER!

The Red Cedar Chapter of the Michgian Botanical Club has been organized in the Lansing area, and is flourishing with over 75 members. Formal installation will take place in April. Temporary officers include Dr. John H. Beaman, chairman; Dr. William B. Drew, vice chairman; and Jesse L. Saylor, secretary-treasurer.

News of Botanists

David M. Gates, Director of the Missouri Botanical Garden and Professor of Biology at Washington University (St. Louis) since 1965, will become Director of the University of Michigan Biological Station this fall. He succeeds Dr. F. K. Sparrow, who will be retiring this summer after serving as Director since the death of Dr. A. H. Stockard in 1966. Dr. Gates will also become professor of botany at the U. of M. A distinguished environmental scientist, Dr. Gates is a member of the National Science Board (National Science Foundation) and chairman of the Environmental Studies Board of the National Academy of Sciences/National Academy of Engineering. In the summers of 1964 and 1970 he was a visiting professor at the Biological Station, and in earlier years he spent many summers there as the son of the late Dr. Frank C. Gates, who taught plant ecology 1915-1954 and who had initiated ecological work in the Douglas Lake region in 1911.

Miss Marjorie Votey died at the age of 77 on February 3, 1971, in Geneva, Illinois. Miss Votey taught at Birmingham and Walnut Lake for 13 years, during which time she was active in the Southeastern Chapter. After moving to Traverse City, she was of major help in establishing the former Northwestern Chapter, which she served as president—carrying on the Botanical Club tradition of her mother, Mrs. F. A. Votey, who was one of the original founders of the Michigan Wildflower Association.

We regret to report the death, on February 16, 1971, of Dr. Lloyd H. Shinners, professor of botany and director of the herbarium at Southern Methodist University, where he had been since 1945. Indefatigable collector, author, editor, and critic, Dr. Shinners almost single-handedly built up (often at his own expense) an outstanding herbarium and botanical library. Born in Alberta September 22, 1918, he received all three academic degrees from the University of Wisconsin, where he was a student of Dr. Norman C. Fassett. His papers on *Aster* and *Panicum* in Wisconsin have helped many botanists in the Great Lakes region with these troublesome genera. Fassett's *Grasses of Wisconsin* drew heavily on Shinners' work. In the summer of 1952, Dr. Shinners taught plant taxonomy at the University of Michigan Biological Station and collected extensively in northern Michigan.

Dr. Roland E. Beschel, plant ecologist on the faculty of Queen's University, Kingston, Ontario, died suddenly on January 22, 1971, at the age of 42. A native of Austria, Dr. Beschel had been on the Queen's University faculty since 1959. His research and collecting were extensive in both southern Canada and the Arctic.

Editorial Notes

Members of the Michigan Botanical Club and the Michigan Natural Areas Council, who have long known of the magnificent McCormick tract in the Upper Peninsula, will be pleased with its official designation as an "Experimental Forest" by the Department of Agriculture. Your editor served on the ad hoc citizen's review committee which met in 1969, and has compiled the summary account on p. 94 from the official Forest Service news release, establishment report, and notice of closure. The photograph on the cover has kindly been supplied by the North Central Forest Experiment Station.

The January number (Vol. 10, No. 1) was mailed January 5, 1971.

CONTENTS

Chromosome Studies on the Spring Beauties, *Claytonia*, in Ontario
T. Reznicek & D. M. Britton 51

Review—The Archaeology of Michigan 62

Notes on the Fungal Association of Two *Monotropa* Species in Michigan
Ella O. Campbell 63

The Southeastern Adder's-Tongue, *Ophioglossum vulgatum* var. *pycnostichum*, Found for the First Time in Michigan
W. H. Wagner, Jr. 67

Some Rare or Unusual Michigan Fungi of 1970
Florence V. Hoseney 75

The Marshall Bog near Itasca Park, Minnesota
Robert Joyal 78

Nature Education Feature—
An Introduction to the Collection and Study of Higher Fungi
Jane I. LaRue 89

Review—The Boletes of Michigan 93

Cyrus H. McCormick Experimental Forest 94

Program Notes 95

News of Botanists 95

Editorial Notes 95

(On the cover: Looking north over Island Lake, Birch Lake in the background, Cyrus H. McCormick Experimental Forest, Baraga County, Michigan. U. S. Forest Service photo. See p. 94.)

33
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Vol. 10, No. 3

THE MICHIGAN BOTANIST

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors should be guided by "Information for Authors" (Vol. 9, p. 62; copies available from the editor).

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THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter) may send $3.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

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THE GENUS *ASTER* IN MICHIGAN. I. DISTRIBUTION OF THE SPECIES

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Aster is a cosmopolitan genus of 200-250 species, most of which occur in North and Central America. Approximately 32 species are native to Michigan. Most of these are weedy and may be found in waste areas and abandoned fields, along roadsides and edges of woodlots, and similar disturbed habitats. They flower from late July or early August into November, continuing after early frosts. Because of the size and taxonomic complexity of the genus, this paper makes no attempt to clarify the taxonomy of the genus, but deals only with the distribution of the species in Michigan.

The distribution of a species is a natural phenomenon and results from the complex interactions of the plant with its environment. Distribution maps sometimes better represent the activities of the various collectors than the actual distribution of the species. For example, it is unlikely that *Aster macrophyllus* (Map 11) is found in surrounding counties but does not occur in Eaton, Branch, and Hillsdale counties. More likely, it just has not yet been collected in these counties.

Although distribution maps are incomplete and do not show the complete full distribution of the species, they do illustrate, and probably quite accurately, the general occurrence of the species. This certainly is the case with the commonly collected genera; and therefore, valid conclusions may be drawn from these maps. One must acknowledge, however, that with the frequency of long distance travel today, seeds are likely to be transported for long distances, where they may become established far outside of their normal range and distortions of the natural range will occur.

A few species of *Aster* are difficult to identify, and resulting problems may be reflected in distribution maps illustrating data derived from specimens of those species. *Aster lateriflorus, A. pilosus,* and *A. simplex* can usually be determined, but forms approaching the extremes of variation may be very difficult to identify. *Aster praealtus, A. tradescanti,* and *A. vimineus* are easily confused with these species also. I have not seen the latter three species in the field, and from examination of herbarium specimens I do not feel that I know them. Therefore, the determinations on herbarium sheets which appeared reasonable on the basis of my current understanding of these species have been accepted and mapped. More work is required to clarify this group of species. Distinguishing *A. ciliolatus* and *A. sagittifolius,* especially in the areas where the two species overlap, may be difficult.

Throughout the genus, taxonomic problems result from hybridization, polyploidy, sensitivity to fluctuations of environmental factors, and even circumscription of the various species. Many species exhibit considerable phenotypic plasticity.

Approximately 3000 herbarium specimens of Michigan Asters were examined in this study; however much of the data included in the maps was gathered prior to 1961. Many specimens of *Aster* have been added to the herbaria since that time and therefore these maps should be considered preliminary prior to rechecking the herbaria and also prior to attempts to fill in collecting gaps reflected on the maps. I will be happy to identify duplicate specimens sent to me.

Some ecological observations made in the field are included. Relative frequency of each species is indicated by one of three arbitrarily derived terms: common, frequent, or uncommon. These terms are based on a combination of the number of specimens in the herbaria, distribution, and the expectation one might have of finding the species without precise locality data to guide him. The taxonomy and nomenclature of Fernald (1950) are those followed in this paper. A future paper will present an illustrated key to the species of Michigan Asters. Descriptions and keys may be found in one of the manuals commonly used in this area (Fernald, 1950; Gleason & Cronquist, 1963; or Smith, 1966) and in Shinners (1941).

OBSERVATIONS

Aster ×*amethystinus* Nutt. (Map 1). This is a naturally occurring hybrid between *A. novae-angliae* and *A. ericoides* and should be found in open, disturbed areas in the southern half of the Lower Peninsula where the two parent species grow in proximity. Uncommon.

Aster azureus Lindl. (Map 2). This species is found in open or sparsely shaded, sandy areas, mostly in the southern two-thirds of the Lower Peninsula. Frequent.

Aster brachyactis Blake. (Map 3). This rayless species has a local distribution in sandy, saline areas. Uncommon.

Aster ciliolatus Lindl. (Map 1). Shaded roadsides, woodlot edges, and clearings are the habitat of this species. It is the only species in section *Aster* which has a basic chromosome number of $x = 9$ and a northern distribution. Collections from Crawford, Kent, and Ogemaw Counties in the Lower Peninsula, although south of the normal range of the species, are apparently good *A. ciliolatus.* Common.

Aster cordifolius L. (Heart-leaved or Blue Wood Aster). (Map 4). A rather variable species, it occurs in wooded areas in the southern half of the Lower Peninsula. Specimens identified as *A. lowrieanus* probably should be included here. Common.

Aster dumosus L. (Map 5). Mostly moist, sandy areas, widely scattered throughout the state, are the habitat of this species. Uncommon.

Aster ericoides L. (White or Heath Aster). (Map 6). The dry, sandy relict prairie areas in the southern half of the Lower Peninsula are the habitat of this species. The collections from Menominee County are undoubtedly from populations which have invaded from the prairies of Wisconsin where the species is common. Uncommon.

Aster furcatus Burgess. (Map 3). One collection from Monroe County is the only specimen of this species from Michigan. We are northeast of the normal range of this species. Uncommon.

Aster junciformis Rydb. (Map 7). Bogs and sandy lake shores throughout the state are the habitat of this species. Common.

Aster laevis L. (Smooth Aster). (Map 8). This highly variable species occurs in moist to dry disturbed habitats throughout the Lower Peninsula. It is apparently uncommon in the Upper Peninsula for fewer than 20 Upper Peninsula specimens are in the Michigan herbaria. Common.

Aster lateriflorus (L.) Britt. (Calico Aster). (Map 9). This is a common, weedy, highly variable species occurring in moist to dry open fields and waste areas throughout the state. Common.

Aster lowrieanus Porter. (Map 10). A few collections of this species come from woodland areas and are widely scattered in the state. Michigan is west of the normal range of this species; and Michigan collections assigned to this species may be only extreme variants of *A. cordifolius.* Uncommon.

Aster macrophyllus L. (Large-leaved Aster). (Map 11). This rather variable species is common in wooded areas throughout the state. It is shade-loving and I have found very few populations situated so that they received any direct sun after midmorning. Common.

Aster modestus Lindl. (Map 10). The only Michigan collections of this species are from Isle Royale, which is at the extreme eastern edge of the range of the species. Uncommon.

Aster nemoralis Ait. (Map 12). The bogs of the eastern end of the Upper Peninsula are at the western limits of the distribution of this species. Uncommon.

Aster novae-angliae L. (New England Aster). (Map 12). Rich, moist open fields and roadsides in the southern half of the Lower Peninsula are the habitat of this species. Common.

Aster patens Ait. (Map 14). The few collections of this species are from dry open areas or woodlot edges in Oakland and Ingham counties. Uncommon.

Aster pilosus Willd. (Map 13). This is another rather variable, weedy species occurring in dry to moist open areas, mostly in the southern half of the Lower Peninsula. Common.

Aster pilosus var. *pringlei* (Gray) Blake. (Map 14). The moist sandy areas along the shores of the Great Lakes provide the habitat for this variety of *A. pilosus.* Frequent.

Aster praealtus Poir. (Map 15). The few collections of this species come from widely scattered areas in Michigan. It ought to be found in moist low areas. Uncommon.

Aster prenanthoides Muhl. (Map 15). One questionable specimen comes from Keweenaw County. This specimen may be an extreme variant of *A. laevis* rather than a normal specimen of *A. prenanthoides.* Uncommon.

Aster ptarmicoides (Nees) T. & G. (Map 16). Scattered collections of this species are mostly from dry sandy areas throughout the state. Frequent.

Aster puniceus L. (Red or Purple-stemmed Aster). (Map 17). This species is abundant in rich, low, wet areas and ditches throughout the state. Common.

Aster sagittifolius Wedem. ex Willd. (Arrow-leaved Aster). (Map 18). This variable species occurs in open woods or fields with moist to dry soil. It is abundant in the southern half of the Lower Peninsula. Relatively few collections are from elsewhere in the state. Common.

Aster schreberi Nees. (Map 16). The few Michigan collections are from Bay and Washtenaw counties. Uncommon.

Aster sericeus Vent. (Map 19). In Michigan this species occurs primarily in the relict prairie areas of the western portion of the Lower Peninsula. Uncommon.

Aster shortii Lindl. (Map 20). This is a plant of woodland edges in the southern half of the Lower Peninsula. Uncommon.

Aster simplex Willd. (Panicled White Aster). (Map 21). This is another abundant, weedy, and highly variable species occurring in ditches and other low wet areas throughout the state. Common.

Aster subulatus Michx. (Map 19). This is a plant of the saline marshes of the eastern and southern coastal regions of the U. S. Collections from Wayne County appear to be this species. Uncommon.

Aster tardiflorus L. (Map 20). The only Michigan collections of this species are from Isle Royale. Michigan is west of the normal range of the species. Uncommon.

Aster tradescanti L. (Map 22). This is a plant of low moist areas throughout the state. Uncommon.

Aster umbellatus Mill. (Map 23). Low wet areas and ditches to sandy woods throughout the state are the habitat of this species. Frequent.

Aster vimineus Lam. (Map 24). The few Michigan collections of this species are from scattered, moist open areas throughout the state. Uncommon.

ACKNOWLEDGMENTS

I would like to acknowledge the assistance of Fern Sterk in the preparation of this paper. Financial assistance for the field work was provided in part by a Hope College Faculty Summer Grant and a Shell Oil Company Grant administered by Hope College. I would also like to thank the curators of the herbaria at Cranbrook Institute of Science, Michigan State University, The University of Michigan, Wayne State University, and Western Michigan University for making their collections available to me.

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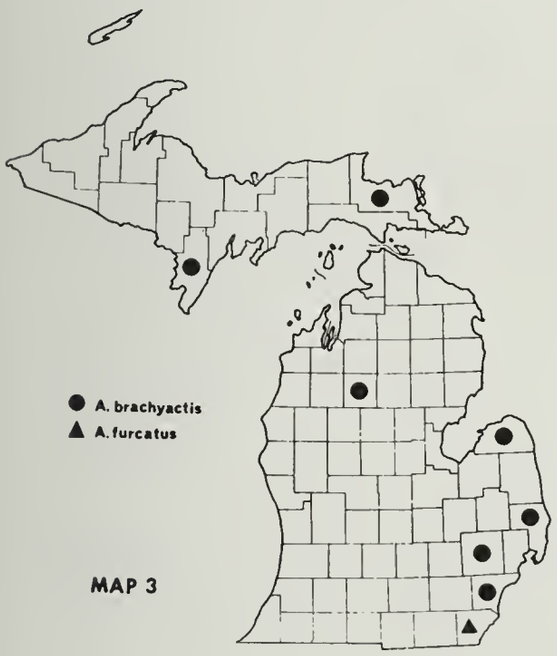
MAP 1

MAP 2



MAP 3

MAP 4

MAP 5

MAP 6

MAP 7

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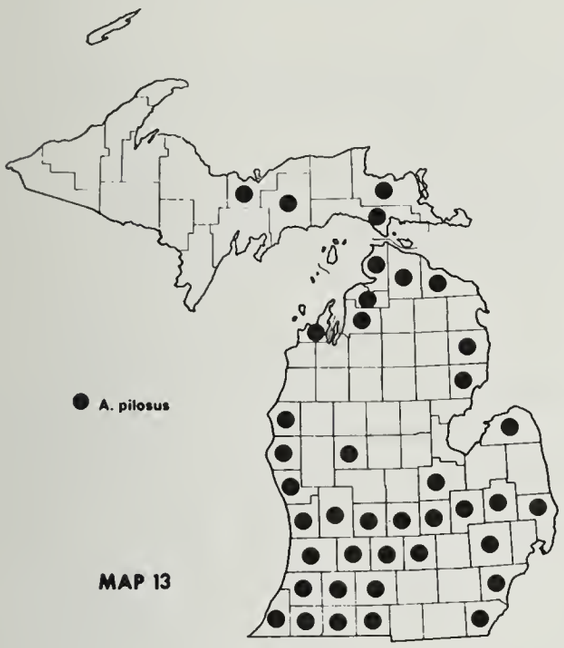
MAP 11

MAP 12



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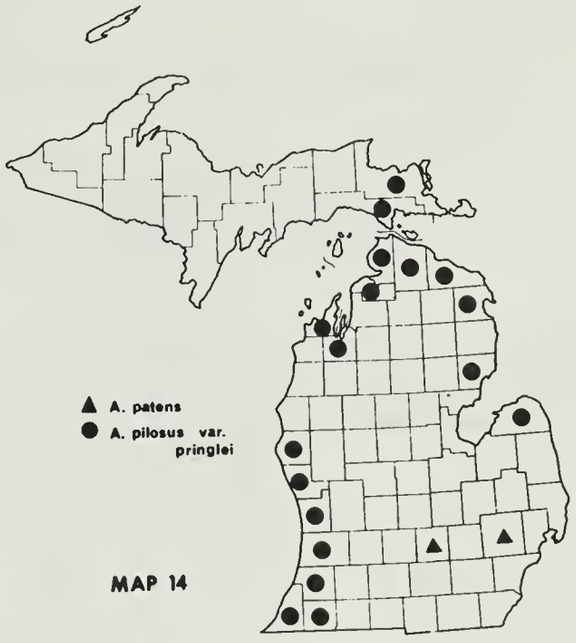


MAP 14

MAP 15

MAP 16

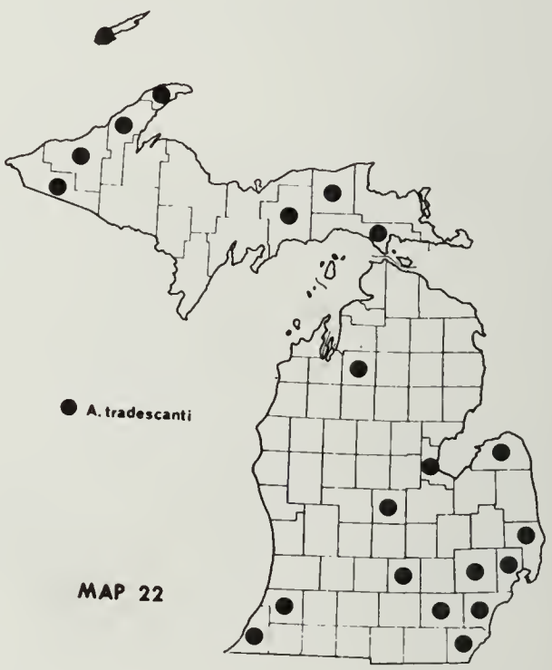
MAP 17

MAP 18

MAP 19

MAP 20

MAP 21



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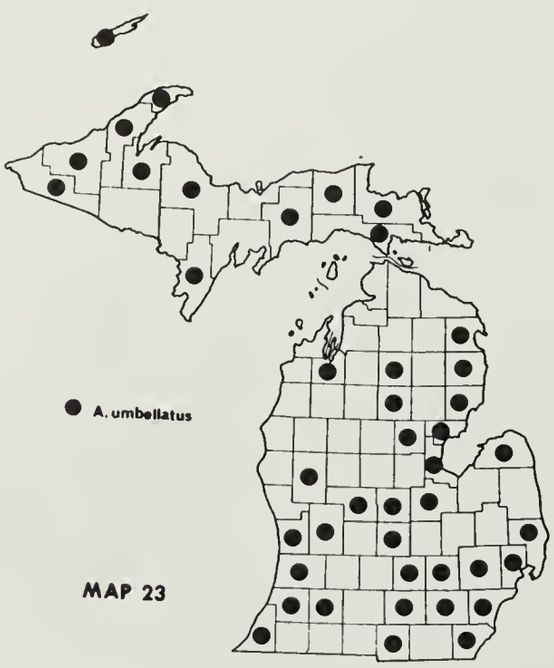
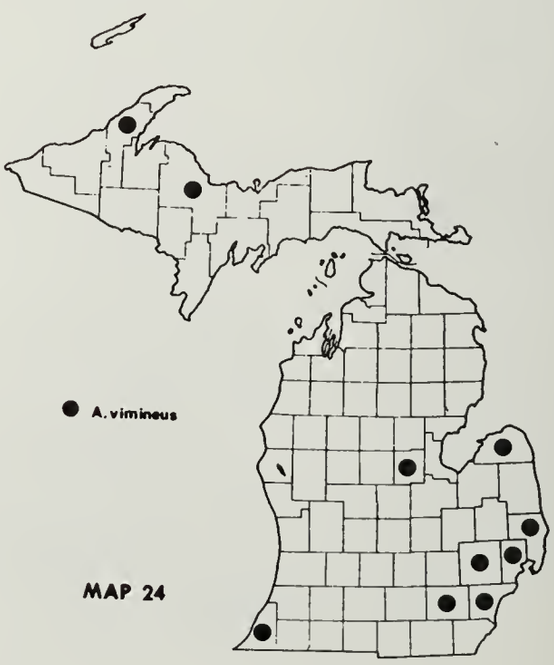


MAP 23



MAP 24

TWO NEW SPECIES OF *HYPOMYCES* FROM MICHIGAN

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University Herbarium, The University of Michigan, Ann Arbor

During the summer of 1967 one of us (Mazzer) collected parasitized specimens of a rhodophylloid agaric in which the gills were aborted and the pilei were covered with perithecia (Fig. 1). Subsequent study of the parasite indicated that it was an undescribed species of *Hypomyces.*

Also in 1967 when *Tylopilus rubrobrunneus* Mazzer & A. H. Smith (Mich. Bot. 6: 58-59. 1967) was described, aborted (parasitized) carpophores were illustrated (Mich. Bot. 6: 64, 65, figs. 14, 15. 1967). These aborted specimens were suggestive of specimens of an aborted bolete bearing perithecia (Fig. 2) collected near Ann Arbor by Paul Marchand in 1961. Study of this material revealed that it too was an undescribed species of *Hypomyces.*

Thus two new species of *Hypomyces* from Michigan can be described.

Hypomyces porphyreus Rogerson & Mazzer, sp. nov. Figs. 1, 3-6.

Subiculum sparsum, byssinum, colore lateritium; hyphae septatae, ramosae, 2-3 μ crassae, cellulis compluribus irregulariter inflatis, tunica levi. Perithecia dense aggregata, mollia et carnosa, papillato-globosa, 300-385 × 220-275 μ, corpore rubro-brunneo vel lateritio vel castaneo, papilla distincta, obscure rubro-brunnea vel brunneo-atra; periphyses filamentosae, 10-15 × 1-1.5 μ. Asci octospori, elongato-cylindrici, (125-)150-165(-190) × 4-5 μ, apice incrassato, poro distincto perforato. Ascosporae oblique uniseriatae, hyalinae, verruculosae, cylindrico-fusiformes, (20-)25-28(-30) × 3.5-5 μ, unicellulares vel bicellulares septo medio, utrinque anguste obtusae vel acutae. Typus: In basidiocarpio *Leptoniae strigosissimae* (Rea) Orton, re publica Michigan legit Samuel J. Mazzer sub numero 4969 (holotypus, NY; isotypus, MICH).

Subiculum sparse, cottony, brick red, occurring at margin of perithecial layer and between perithecia; subicular hyphae (Fig. 5) filamentous, branched, thin-walled, smooth, septate, at first 2-3 μ in diameter, but in age some cells becoming irregularly enlarged, up to 10 μ in diameter, at first forming a thin layer on surface of host pileus, disappearing as perithecia develop. Perithecia (Fig. 6) forming a compact layer over entire surface of host pileus, globose-papillate to flask-shaped, 300-385 × 220-275 μ; body brown mixed with red tints, or dark brick red, bay or chestnut-colored; papilla distinct, darker, red-brown when dry, brownish black in 3 percent KOH; outer wall tissue varying from prosenchymatous to irregularly pseudoparenchymatous; in surface view cells 5-10 × 3-5 μ, forming a wall of 4 to 5 layers; hyphae of papilla oriented vertically with somewhat swollen apices; periphyses 10-15 × 1-1.5 μ, lining the ostiolar canal, curved upward, with obtuse apices; mature centrum filled with asci which line the bottom and lower portions of the walls; apical paraphyses

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Fig. 1. *Hypomyces porphyreus* on *Leptonia strigosissima*, X 1 (*Samuel J. Mazzer 4969*, fresh specimens).
Fig. 2. *Hypomyces melanocarpus* on aborted bolete (probably *Tylopilus rubrobrunneus*), X1 (*A. H. Smith 64259*, dried specimens).

not seen. Asci (Fig. 4) 8-spored, long-cylindric, (125-)150-165(-190) × 4-5 μ, thin-walled except at apex; apex thickened, 1-2 μ, with a distinct pore, tapering to a foot-like base. Ascospores (Fig. 3) obliquely uniseriate in ascus, cylindric-fusiform, (20-)25-28(-30) × 3.5-5 μ, one- or two-celled with median septum, verruculose, hyaline; ends narrowly obtuse to slightly acute.

On *Leptonia strigosissima* (Rea) Orton with malformation of the pileus and abortion of the gills (basidiospores of host present).

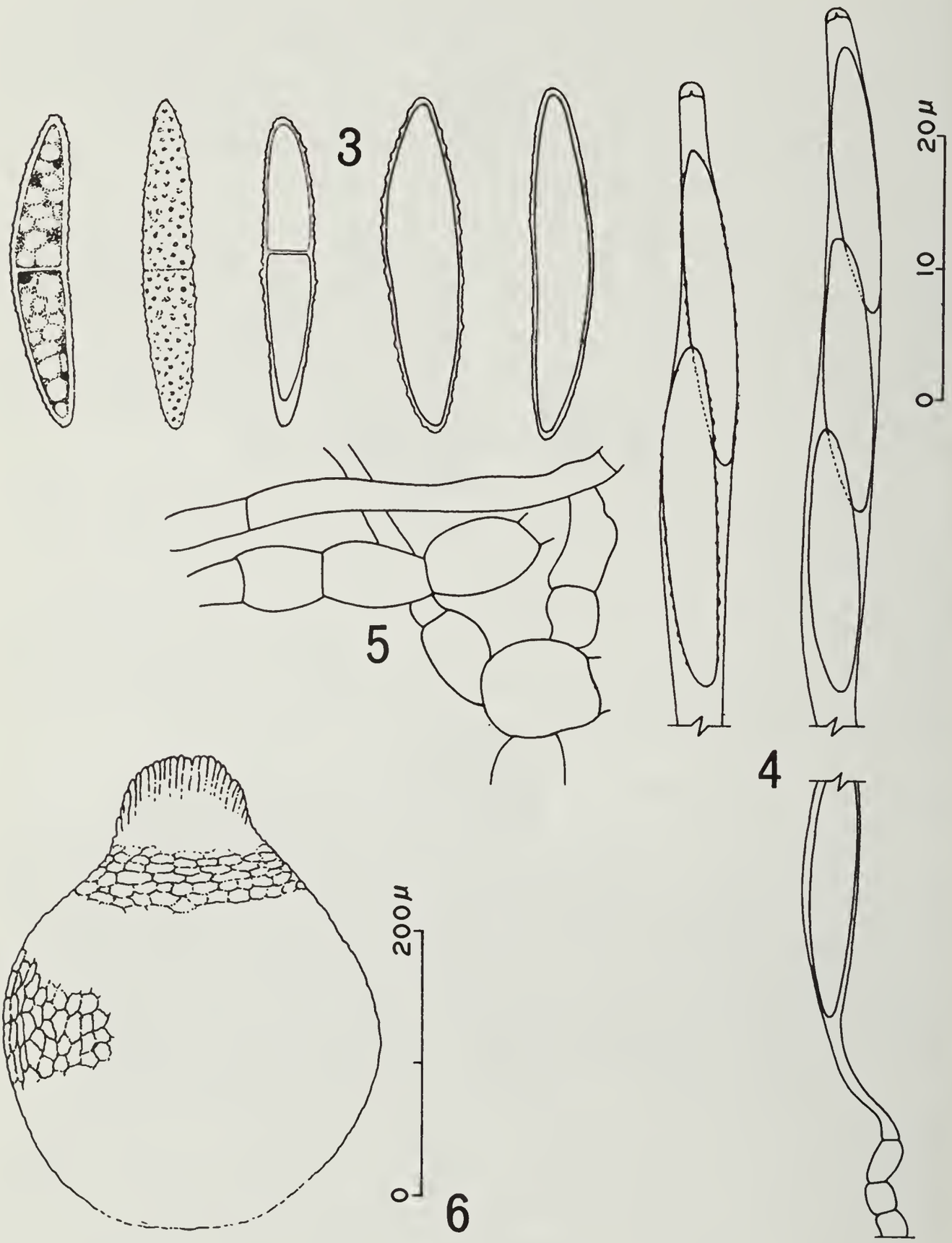
UNITED STATES. Michigan: Cheboygan County: near junction of Bryant's Road and Robinson Road, 21 Jul 1967, *Samuel J. Mazzer 4969* (holotype, NY; isotype, MICH); black mucky soil, small swampy area, same locality, 14 Jul 1967, *Samuel J. Mazzer 4930* (MICH); mucky soil, swamp margin, same locality, 13 Aug 1967, *Samuel J. Mazzer 5155* (MICH); black moist soil under mixed hardwoods, along edge of low swampy area, same locality, 15 Aug 1967, *Samuel J. Mazzer 5161* (MICH); low mucky bank along stream, across from Reese's Bog, north of Burt Lake, 27 Aug 1967, *Patricia A. Mazzer 156* (MICH). Emmet County: moist black mucky soil along southwest side of Wycamp Lake, 5 Aug 1967, *Samuel J. Mazzer 5055* (MICH).

This species is distinctive in several respects. The nonapiculate ascospores suggest an alliance with *Hypomyces cervinigenus* Rogerson & Simms and with *H. chrysostomus* Berkeley & Broome. From *H. cervinigenus* it differs in having verruculose ascospores; from *H. chrysostomus* it differs in the much larger ascospores. It can be distinguished from these species, as well as all other species of *Hypomyces,* in the host, a member of the rhodophylloid agarics. The species has not been obtained in culture. No evidence suggesting an imperfect state has been found associated with the perithecia.

Hypomyces melanocarpus Rogerson & Mazzer, sp. nov. Fig. 2, 7-11.

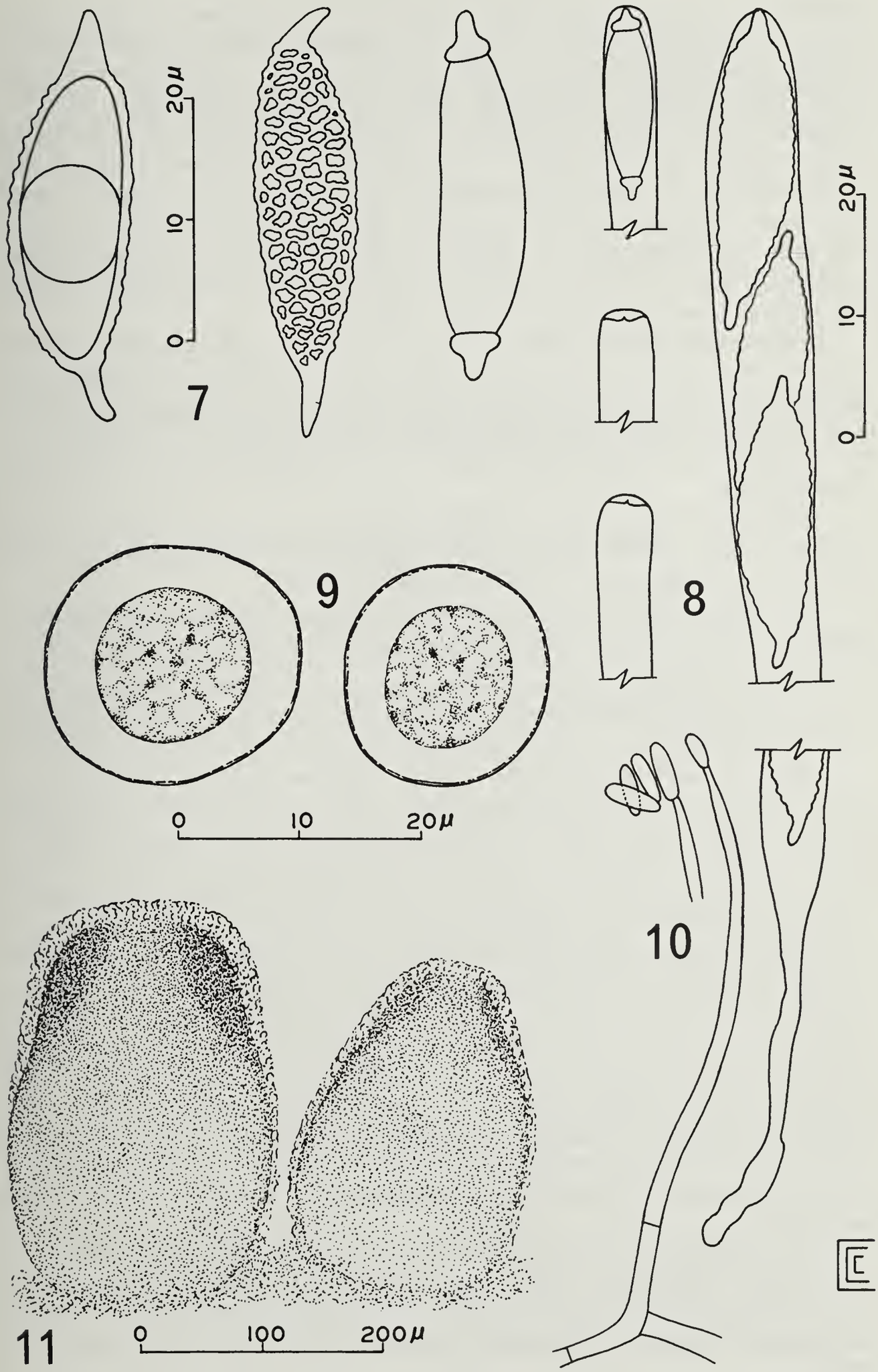
Subiculum laxe byssinum, album in alutaceum vergens; hyphae sparse septatae, sparse ramosae, 1-3 μ crassae, cellulis paulum inflatis, tunica laevi. Perithecia sparsa vel dense aggregata, mollia et carnoso-gelatinosa, olivacea vel fusco-brunnea vel nigra, (250-)315-330 × (125-)220-240(-245) μ, globoso-turbinata, apice lato; periphyses filiformes, 10-20 × 1.5 μ. Asci octospori, elongato-cylindracei, (95-)100-250 × (5-)8-10 μ, apice incrassato, poro perforato. Ascosporae oblique uniseriatae, hyalinae, verrucosae, fusiformi-apiculatae, (28-)30-35(-38) × 7.5-10 μ, apiculis acutis, 2-5 μ longis. Typus: In basidiocarpio boleti (?*Tylopili* sp.), parasitans, in re publica Michigan legit Paul Marchand (sub numero A. H. Smith 64259) (holotypus, NY; isotypus, MICH).

Subiculum covering the stipe and pileus of the host, at first white, becoming buff-colored, loose-cottony, disappearing as perithecia become compacted; hyphae hyaline, smooth, septate, interwoven, sparsely branched, uniformly 1-3 μ in diameter; cells swelling in 3 percent KOH except at septa. Perithecia (Fig. 11) scattered to densely aggregated and forming a black crust on the host, projecting above the subiculum, dark brown to brownish black or black when dry, olivaceous to reddish brown in 3 percent KOH, (250-)315-330 × (125-)220-240(-245) μ, globose-turbinate with broad apex, not distinctly papillate, soft and gelatinous, with bases immersed in subiculum; wall tissue in surface view consisting of narrow interwoven hyphae, mostly remaining prosenchymatous, in lower portion often pseudoparenchymatous, in longitudinal section 5-10 layers thick, the cells rectangular; hyphae of apex



Figs. 3-6. *Hypomyces porphyreus* (*Samuel J. Mazzer 4969*). 3. Ascospores. 4. Asci. 5. Subicular hyphae. 6. Perithecium.

Figs. 7-11 (facing, on p. 111). *Hypomyces melanocarpus (A. H. Smith 64259)*. 7. Ascospores. 8. Asci. 9. Chlamydospores. 10. Conidiophore and conidia. 11. Perithecia.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11

parallel with narrow obtuse tips; hyphae on outer surface of apex densely interwoven and with swollen tips, an amorphous gelatinous exudate covering the upper portion; periphyses 10-20 × 1.5 μ, filiform, curved upwards, with obtuse apices, lining the ostiolar canal; centrum at first filled with filamentous, septate apical paraphyses, at maturity filled with asci lining the lower portions of the interior wall. Asci (Fig. 8) 8-spored, long-cylindric, (95-)100-250 × (5-)8-10 μ, thin-walled except at obtuse apex; apex thickened, 1-1.5 μ, with distinct pore; base tapering into an irregularly swollen group of foot cells. Ascospores (Fig. 7) obliquely uniseriate in ascus, fusiform-apiculate, (28-)30-35(-38) × 7.5-10 μ, hyaline, one-celled, with prominently verrucose wall; apiculi acute or sometimes blunt, 2-5 μ long.

Associated conidial fungus (Fig. 10) on the white subiculum between perithecia and at the margin, with erect, hyaline, tapering, unbranched, non-septate or rarely septate conidiophores 40-60 × 2-3 μ arising from prostrate hyphae; conidia hyaline, one-celled, elliptic, oblong-elliptic or fusiform, 4.5-7.7 × 2-3 μ, produced singly at the apex of the conidiophore, sometimes forming irregular heads.

Associated chlamydospores (Fig. 9) globose, (12-)15-20(-22) μ, or occasionally ovoid, 25 × 15 μ, dull yellow-brown, thick-walled, the wall (2-)3-5(-6) μ in diameter, smooth or slightly wrinkled.

On pileus and stipe of a bolete (probably *Tylopilus rubrobrunneus* Mazzer & A. H. Smith), the hymenophore aborted and malformed.

UNITED STATES. Michigan: Washtenaw County: Ann Arbor, oak-hickory woods, 5 Sep 1961, *Paul Marchand s. n. (A. H. Smtih 64099)*, immature (MICH, NY); 12 Sep 1961, *Paul Marchand s. n. (A. H. Smith 64259)* (holotype, NY; isotype, MICH).

This species differs from other described boleticolous species of *Hypomyces,* such as *H. chrysospermus* (Fries) Tulasne and *H. tulasneanus* Plowright, in ascospore characteristics as well as in color, size and shape of perithecia and in associated imperfect states. The ascospores of *H. melanocarpus* remain one-celled; those of *H. chrysospermus* and *H. tulasneanus* are unequally two-celled. In contrast to the black perithecia of *H. melanocarpus,* the perithecia are orange-yellow to red-brown in *H. chrysospermus* and yellow to light brown in *H. tulasneanus.* Since *H. melanocarpus* has not been cultured, the genetic connection between the associated imperfect states has not been proven. The close association certainly suggests that they are the conidial and chlamydosporic states of *H. melanocarpus* and should be referred to the form-genus *Sepedonium.* In contrast to the globose, dull brown, smooth or slightly wrinkled chlamydospores associated with *Hypomyces melanocarpus,* the chlamydospores of *H. chrysospermus* are golden-yellow and prominently verrucose; those of *H. tulasneanus* are narrowly oval to oblong, pale brown and verrucose.

The perithecia of *Hypomyces luteovirens* (Fries) Tulasne sometimes appear dark and black, thus suggesting *H. melanocarpus.* However, *H. luteovirens* typically has yellow-green, bright green, or olivaceous perithecia, is known only on species of *Russula,* and has no known or suspected imperfect state.

ACKNOWLEDGMENTS

We wish to thank Dr. Alexander H. Smith for the photograph (Fig. 1) of *Hypomyces porphyreus* and for making available to us the specimens of *Hypomyces melanocarpus*. We are indebted to Dr. Donald P. Rogers for the Latin descriptions and to Mr. Charles Clare for the drawings. Rogerson's portion of the research was supported in part by NSF Grant GB-2694.

CHANGING ABUNDANCE OF TWO SPECIES OF *LINUM* IN EASTERN NORTH AMERICA

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Linum virginianum L. and *L. medium* (Planch.) Britton var. *texanum* (Planch.) Fern., two taxa of yellow-flowered flax, are widespread perennial herbs of eastern North America. The first is primarily a species of more or less open woodlands and does not generally long withstand the wholesale removal of the tree cover. The latter, on the other hand, is a plant of old fields, meadows, damp swales, and other open, sunny places which have remained relatively unchanged. It is certainly not a weed in the usual sense of the word, but there is little doubt that opening up of the forest frequently provides a situation favorable for its ultimate establishment. Both taxa are rather unimportant little plants and there should be no intentional selection by man for or against either of them. They are quite similar in stature and conspicuousness and so, except that the habitat of *L. medium* var. *texanum* is often more accessible than that of *L. virginianum,* the number of collections of each should give a rough idea of their relative abundance. This in turn might provide some objective information about the availability of habitats for each, which are different and upon which man's activities might have a particular effect. Collection data on a very extensive series of specimens of these two plants, dating back to the early 1800's, are available from an earlier study (Rogers, 1963). When these data are tabulated, the results are hardly unexpected, and yet, because they provide long-term information about specific plants, they are thought worthwhile to present here.

The geographical range of *L. medium* var. *texanum* exceeds that of *L. virginianum.* This fact is reflected in the number of specimens available for each. A total of 1387 collections of *L. medium* var. *texanum* and 627 of *L. virginianum,* from approximately fifty herbaria, were examined. The year of

collection of each specimen was noted and this information assembled into ten-year subtotals, beginning with 1820-29 and ending with 1950-59. The results are shown in Fig. 1.

Through the 1850's, the collections were few and sporadic (only nineteen total collections of both species through the forty-year period 1820-59) so that direct comparison of numbers has little meaning. During the period from 1861 through the 1920's, the number of *L. virginianum* collections fluctuated from 87% (1880's) to 65% (1910's) of the number of *L. medium* var. *texanum* collections, averaging about 74% over that seventy-year period. It would appear that prior to 1930, in view of its smaller range, *L. virginianum* was as plentiful as, and very probably more plentiful than, *L. medium* var. *texanum* in those regions where both grew.

Beginning with the 1930's a very dramatic change in the comparative number of collections of the two plants took place. During the ten-year period beginning with 1930, *L. virginianum* collections amounted to only 43% of those of *L. medium* var. *texanum*; in the 1940's they were just 29%; during the 1950's, 13%. During the last decade of the survey, in fact, the number of *L. medium* var. *texanum* collections increased very rapidly at the same time that that of *L. virginianum* was declining. The number of collections of *L. virginianum* made in recent decades never exceeded the peak reached in the 1890's.

Some distributional factors, other than habitat availability, which might bear on the numbers of collections could be mentioned. In some areas where, of the two plants, only *L. medium* var. *texanum* is found, collections might bias the record toward it, especially if there has been considerable activity in recent years. Tabulation of collections from Florida, which might serve as an example of that kind of area, shows that plants collected in such places tend to add to the curve more or less proportionately through the years and so add to the height of the curve for *L. medium* var. *texanum* but do not change its trend. Of some interest are the Carolinas where perhaps the greatest concentration of field activity in recent years has been that which preceded the publication of the Flora of the Carolinas (Radford, Ahles, & Bell, 1964) and the forthcoming Vascular Flora of the Southeastern United States. The work there has been a large factor in the great increase in number of plants collected in the 1950's. When the data for North Carolina are examined, they prove to be quite similar to those for the whole of eastern United States: up through the 1920's, essentially the same number of collections for each taxon had been made (eight collections of *L. medium* var. *texanum* vs. six for *L. virginianum*); beginning in the 1930's and becoming accentuated in the 1950's, collections of *L. medium* var. *texanum* became more numerous than those of *L. virginianum* (73 for the former vs. 13 for the latter in the 1950's). Even so, as a result of the intense collecting there, this is one of the few areas where the number of collections of *L. virginianum* was greater in the 1950's than in any previous decade.

A final example will illustrate the local change in abundance of the two plants. I had occasion several years ago to search for *Linum* through most of

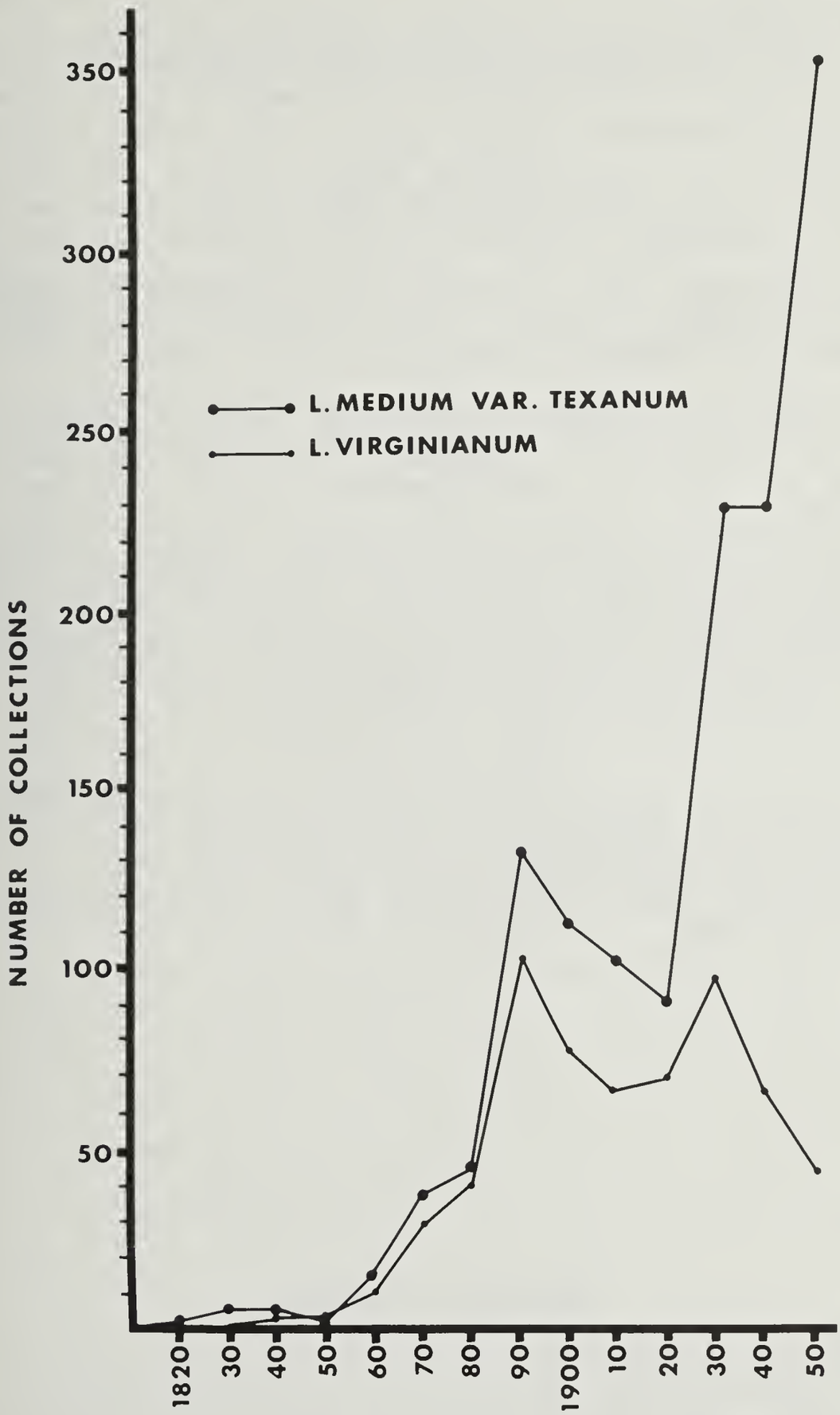

Fig. 1. Distribution of collections of *L. medium* var. *texanum* and *L. virginianum*, 1820-1959, divided into 10-year periods. (1820=1820-29, etc.)

the local Michigan herbaria (Rogers, 1957), and since then have examined Michigan specimens of the genus in most of the larger herbaria in the United States, so that a very nearly complete record of collections for the state is known. The state is on the periphery of the range of the two plants and neither has been frequently collected. I have a record of eleven collections of *L. virginianum*, but none after 1938. Of the seventeen collections of *L. medium* var. *texanum,* eight are from the 1930's and later. I have been on the lookout for populations of *Linum* in the state, where I may obtain living material, seeds, etc. I know of ten or a dozen places where I can find *L. medium* var. *texanum*; I have yet to see a colony of *L. virginianum* in the state, and find it necessary to travel to northern Indiana to collect this species!

In summary, as revealed by the relative number of collections of *L. medium* var. *texanum* and *L. virginianum,* it seems quite reasonable to conclude that the former has become much more common, particularly during the last thirty years, and that the latter may, in fact, have become significantly less common during the same period. The availability of *L. medium* var. *texanum* habitats to the collector and the comparative ease with which he might find this plant may have played an important role in determining the numbers cited above. It seems safe to conclude, however, that the changing environment due to man's activities is the chief cause.

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Rogers, C. M. 1963. Yellow flowered species of Linum in eastern North America. Brittonia 15: 97-122.

Publication of Interest

A WILDERNESS IN CRISIS–THE BOUNDARY WATERS CANOE AREA. An analysis by The North Star Chapter, The Sierra Club, in co-operation with the Natural History Society. 1970. 32 pp. $2.25 ppd. from Sierra Club, North Star Chapter, Box 933, Minneapolis, Minnesota 55440. An attractively illustrated and carefully documented history of the million-acre BWCA in the Superior National Forest, along the Canadian border of Minnesota. Includes discussion of the wilderness values at stake, present mining and logging problems, incompatible recreational uses, and the implications of future uses. Maps show the designated no-cut zones and the generalized logging history in various portions of the area.

OBSERVATIONS ON SOME AQUATIC PLANTS IN NORTHWESTERN MINNESOTA

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During the summers of 1965, 1966, 1967, 1968, and 1970, while serving on the faculty of the University of Minnesota Forestry and Biological Station at Lake Itasca, I had the opportunity to make a number of observations on aquatic plants. Some of these—on *Heteranthera, Zizania, Ruppia, Potamogeton, Sagittaria,* and *Vallisneria*—I am recording here.

HETERANTHERA

Although I made a special effort to find the bright yellow, emersed flowers of *Heteranthera dubia,* stargrass, a frequent species in the Itasca region, I was successful on only one occasion: a single flower was noted on a small plant stranded on a sandbar in the Mississippi River. It is safe to conclude, I believe, that *H. dubia* flowers rather infrequently in the region—at least it produces *chasmogamous* flowers infrequently. My noting of *cleistogamous* flowers in the species was brought about by my interest in the nature of the basal sheath of the stargrass leaf. Several plants were collected from water ca. 1 m deep at the boat dock of the Station and were examined in the laboratory. I soon discovered that, in many of the leaf axils, apparently cleistogamous flowers had developed. Flowers in all stages—from those in early development to those with maturing fruit—were seen in these and other plants from the dock area. Plants with many cleistogamous flowers were later seen also in the Mississippi River and in Hay Creek, watercourses with a strong swift current. The seemingly "normal" structure of the cleistogamous flowers, especially the presence of the perianth, made me wonder if the cleistogamy was "induced" because the flowers simply did not reach the surface and open normally. They were produced far under the surface, as in Lake Itasca, or in streams where the branches were pulled under water by the current.

The one chasmogamous flower I saw on the Mississippi sandbar made me resolve to try the following experiment. Obtaining four 22 × 14 × 8 cm metal pans, I cut an end panel from each. Then, near the boat dock, four stargrass plants were selected from a depth of ca. 1 m and from a colony in which every individual appeared to be producing cleistogamous flowers. These four I transplanted, one to each pan, by simply pushing the open end of a pan, scooplike, into the soil at the base of a plant, then raising the pan sufficiently to place over its open end a lid-like piece I had made from sheet metal. The plants seemed not to be disturbed at all by the operation. I let the pans remain at the 1 m depth for a day and then moved them, underwater, to water so shallow (about 6 cm deeper than the height of the pans) that the

branches of the stargrass were floating at the surface. Lakeward from the pans I fashioned a dike of sand and gravel to protect the plants from wave action. The following day no change was noted in the plants, but on the morning of the second day, two plants had each produced one apparently normal, emersed, chasmogamous, bright yellow flower. That night the high waves accompanying a violent wind and rain storm ended the mini-experiment by washing away the dike and the transplanted plants. There is no doubt, however, that the two chasmogamous flowers of my experiment would have been cleistogamous flowers if the plants had not been moved to shallow water. It would be of interest to investigate the stimulus that results in the flower's following one of the two paths of development.

Each flower of stargrass arises from an axillary spathe that is, at most, 3 cm long. The flower projects about 2 cm beyond the apex of the spathe. It is patent that the leaf axil must be, then, *less* than 5 cm from the surface for the flower to be able to open in the air. If the axil is deeper, the flower develops cleistogamously. Whether cleistogamous flowers may develop in axils *less* than 5 cm deep I cannot say from personal observation, but Dr. Voss informs me that stargrass which he saw in water 3-4 inches deep in Schoolcraft County, Michigan, was producing such flowers in abundance. Additional observations on cleistogamy in *H. dubia* certainly seem warranted. Wylie's (1917) paper contains many data of value and interest on this subject.

I regard the term "cleistogamous" as being perhaps not appropriate when applied to the non-opening flowers of *H. dubia.* Possibly this term should be restricted to flowers that not only remain closed but also are morphologically different from "normal" flowers of the same species, e.g., *Viola.* Darwin (1889, p. 311-312) mentions that the flowers of certain aquatic plants "remain closely shut as long as they are submerged, and in this condition fertilise themselves. They behave in this manner, apparently as a protection to their pollen, and produce open flowers when exposed to the air; so that these cases seem rather different from those of true cleistogamic flowers. . . ." I suggest that cases such as these might be described as "pseudo-cleistogamous."

ZIZANIA

I have not noted, in botanical literature, any reference to bumble bees visiting the flowers of *Zizania aquatica,* wildrice, or to bees of any kind visiting the flowers of any grass. But, at least at Lake Itasca, medium-sized bumble bees do indeed visit wildrice flowers, at least the staminate ones, from which they collect pollen. On one occasion, from a stationary canoe, a student and I counted at least 25 such bees in a stand of wildrice. I examined the pollen loads from the hind tibiae of two of the insects. The pollen seemed to be all of one kind and was identical to pollen I collected from a wildrice flower. Wildrice staminate flowers are borne in one-flowered pendulous spikelets that open in the morning and drop a few hours later, having shed their pollen. The anthers are large, ca. 5-6 mm long, and contain an abundance of yellow pollen.

Fig. 1. *Ruppia occidentalis,* detached floating sprig. (The vertical line represents a length of 5 cm.)

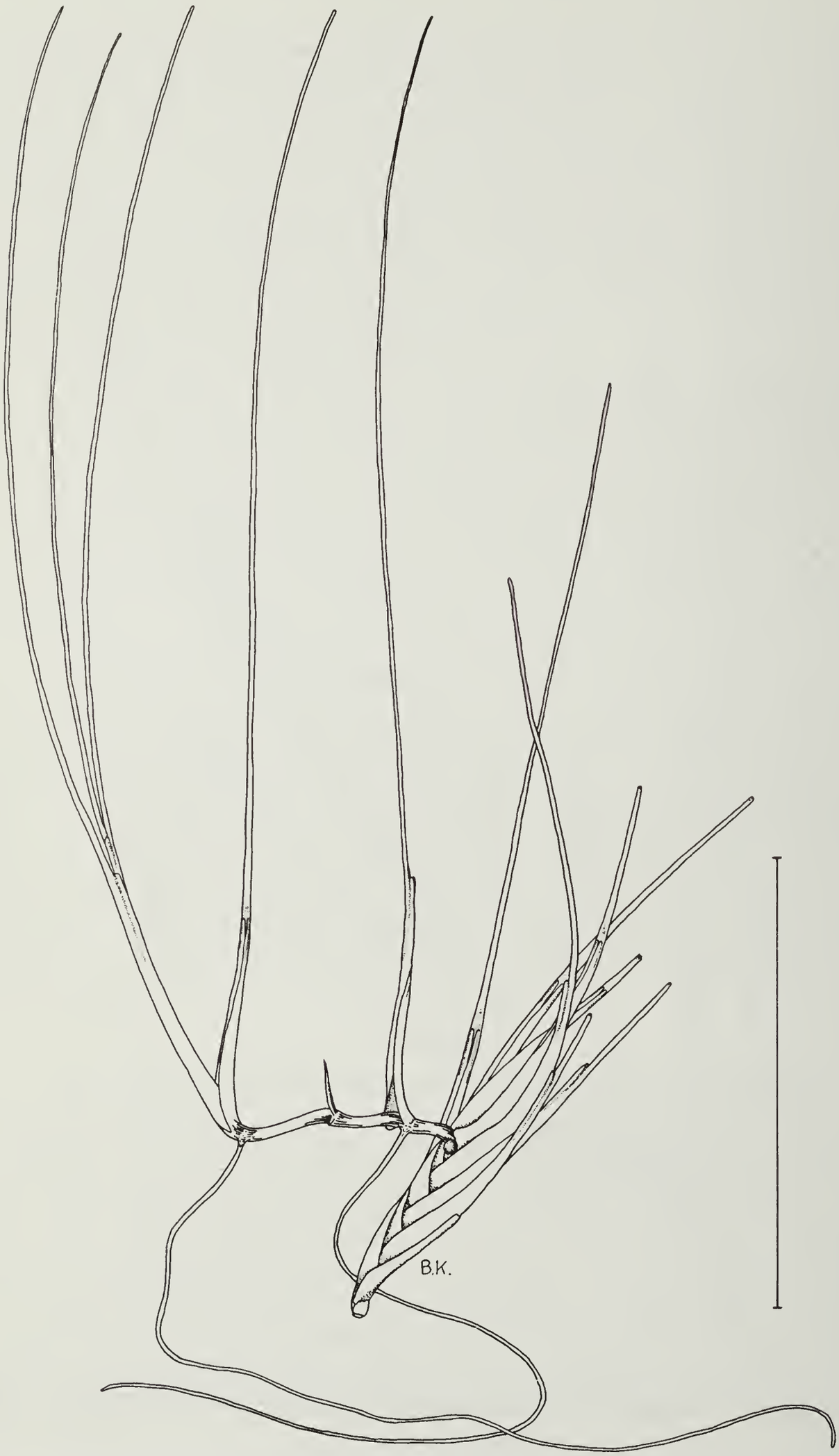

Fig. 2. *Ruppia occidentalis,* detached floating sprig exhibiting shoot and root development. (The vertical line represents a length of 5 cm.)

RUPPIA

I have seen *Ruppia,* widgeongrass, at only one site in the Itasca region—at Warren Lake, about 6 miles northeast of Mahnomen in Mahnomen County. The widgeongrass there is the strikingly robust western plant to which the name *R. occidentalis* has been given. Whether the plant is specifically distinct from *R. maritima* I cannot say, but it certainly is different in appearance from the only *R. maritima* I have seen (in Louisiana). On my first visit to Warren Lake I noted numerous sprigs of *Ruppia* floating among the emergent grasses and sedges along the western shore of the lake. Many of these had produced unbranched roots up to 15 cm long from some of their nodes (figs. 1, 2). On a later visit, and with the help of a waterscope, I found several of these sprigs that had sunk to, and were rooted in, the bottom. Here, then, is apparently a method of vegetative reproduction in *R. occidentalis,* similar to that reported by Graves (1908, p. 117) for *R. maritima:* "At times these currents are even so strong as to detach portions of plants, which I have often observed floating up or down stream, according to the tide. These plant segments become entangled in grass, &c. along the stream edge, or collect in some miniature cove and then begin an independent existence, at perhaps a considerable distance from the parent plant."

POTAMOGETON

According to the literature, one of the distinguishing features of *Potamogeton richardsonii* is that it does not produce floating leaves. Because of this, I was quite surprised to see, in the Fish Hook River near Park Rapids, Hubbard County, a colony of *P. richardsonii* in which several of the stems bore what I would, without hesitation, call floating leaves (fig. 3). Water level in the river had obviously dropped from earlier in the season, bringing the distal parts of the *Potamogeton* stems to the surface. The uppermost leaves were "floating" not only in the sense of being at the surface of the water; they also showed the characteristic features of floating leaves that fit them for life in two worlds, i.e., they bore stomata on the upper surface but not on the lower, and the upper surface was water-repellent but the lower was wettable. These leaves were flat, not crisped like the submersed ones. I certainly cannot imagine what, other than floating leaves, they might be called.

In Long Lake, an oligotrophic lake about 3 miles west of Lake Itasca Post Office, I observed an unusual form of *P. natans* (fig. 4). The plants grew in clear cold water, of rather constant level, about 1.2-1.5 m in depth. None of the leaves reached closer than about 25 cm from the surface. Nevertheless, many of them had well-developed though narrow blades. Lower on the plants were the characteristic bladeless leaves of *P. natans.* These plants are unusual in a species whose underwater leaves are generally described as "without blades" or "phyllodial." Ogden (1943) mentions "transitional" leaves of *P. natans,* referring to leaves transitional between the typical phyllodial underwater leaves and the broad floating ones. Such leaves would presumably be similar to the leaves of the Long Lake plants. However, the Long Lake leaves

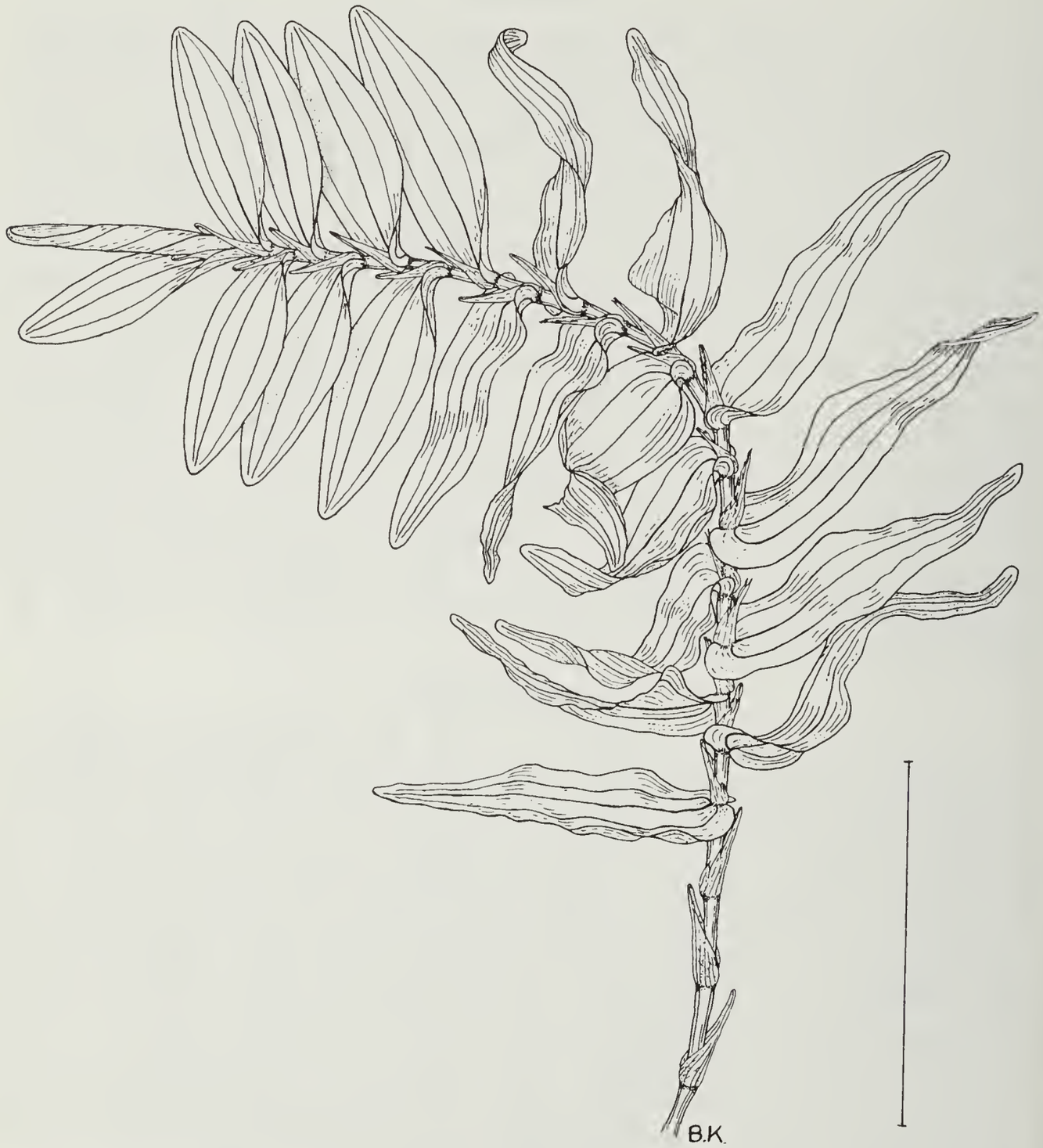

Fig. 3. *Potamogeton richardsonii,* stem with the uppermost leaves of "floating" type. (The vertical line represents a length of 5 cm.)

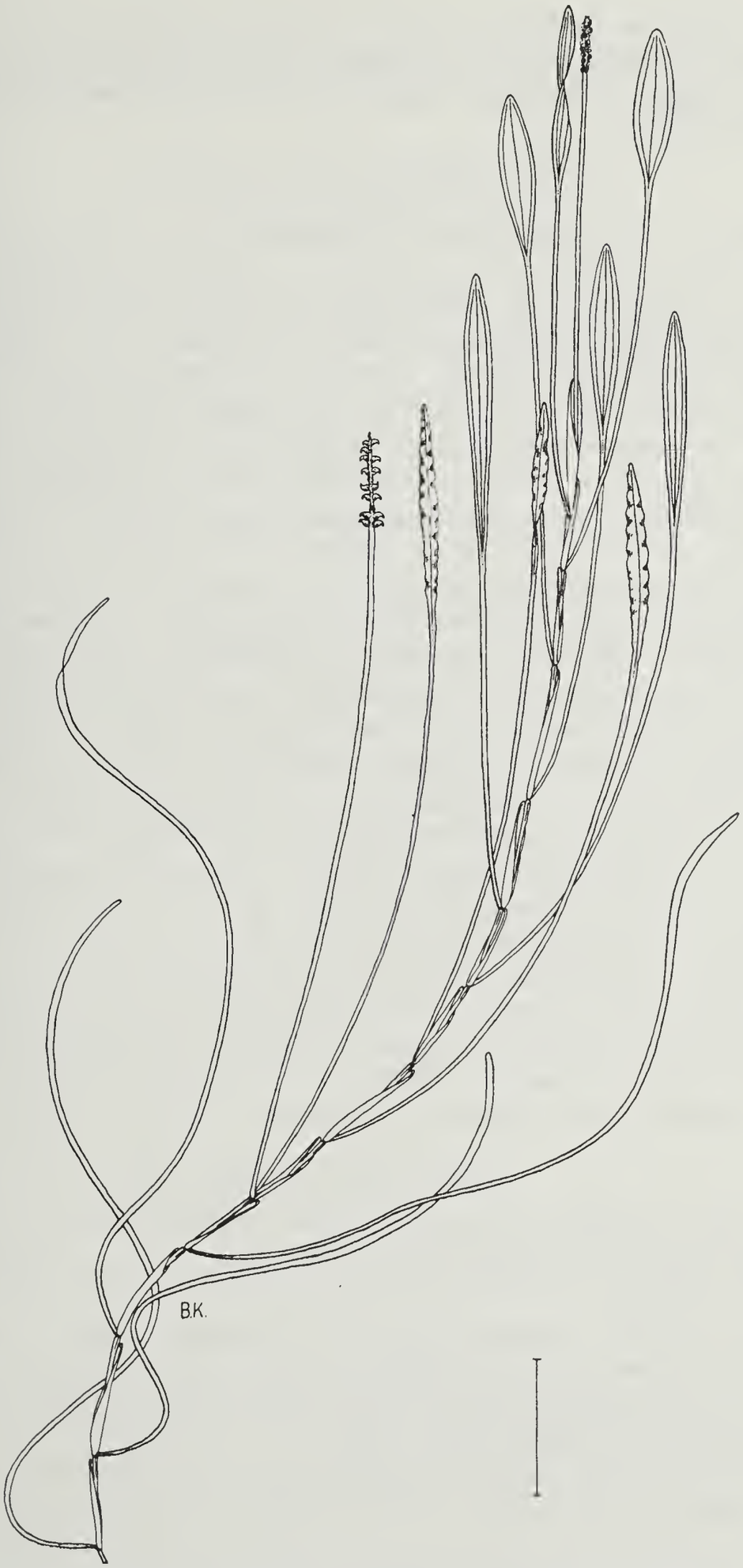

Fig. 4. *Potamogeton natans,* submersed plant with well-developed blades on the upper leaves. (The vertical line represents a length of 5 cm.)

were not transitional to floating leaves because the plants were simply too far beneath the surface to produce floating leaves. During the month that I observed these plants, they came into flower but they did not approach much closer to the surface.

SAGITTARIA AND VALLISNERIA

Vallisneria and certain forms of *Sagittaria*—those with ribbonlike, submersed or partly floating leaves—are easy to confuse in vegetative condition. The feature most frequently relied upon to separate them is the 3-zoned or 3-banded appearance—a light band along each margin and a darker, broader central band—of *Vallisneria* leaves versus the uniform, non-banded appearance of *Sagittaria* leaves. These characteristics are illustrated in Voss (1967). However, *Sagittaria* leaves sometimes show a definite hint of a darker median band; *Vallisneria* leaves do not always show such a band, especially as I have observed *V. americana,* tapegrass, in Louisiana. Tapegrass plants from Lake Itasca showed the band clearly when first transplanted to the laboratory. After two weeks in the laboratory, however, the bands had all but vanished. Flowering *Vallisneria* examined in a Minneapolis aquarium-supply store showed no banding at all. When the banding is visible, it is a distinctive feature, even a striking one, but the uncertainty of its appearance reduces somewhat its value for identification. For the separation of vegetative *Vallisneria* and *Sagittaria* I rely on two additional features: (1) Scale-leaves are absent from the rhizomes of *Vallisneria,* the rhizomes consisting of but a single internode between adjacent rosettes; such leaves are present in *Sagittaria.* (2) *Vallisneria* does not produce milky juice; such juice can generally be seen in *Sagittaria* by simply breaking a leaf in two crosswise and examining the broken ends. My attention was called to the milky juice of *Sagittaria* by students who had noted a copious flow of it from broken rosette-leaves of *S. rigida.* Since then I have observed milky juice in *S. cuneata, S. cristata, S. latifolia,* and other arrowheads. The juice can frequently be seen even without the aid of a handlens. Stant (1964) pointed out that the presence of laticifers is sufficiently constant to be considered a diagnostic feature of the Alismataceae.

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A SAMPLE OF THE SEASONAL OCCURRENCE OF HIGHER FUNGI IN KALKASKA COUNTY, MICHIGAN

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My interest in the higher fungi led me to undertake a problem on "mushrooms" for my master's thesis at Eastern Michigan University, the results of which are presented here. Since my first collections of these fungi were made in Kalkaska County, and since there were few specimens on record from that locality, it seemed logical to concentrate on that area when making a sequential collection of fungi from different habitats during the fruiting period of 1968. In this way, a contribution to the knowledge of the flora of Michigan would be made.

It is common knowledge that fungi fruit according to a pattern each season in a particular locality and vary from one season to the next due to different environmental conditions which may prevail. In this study, the seasonal sequence is given for those species collected during 1968. Such a record furnishes a basis for comparing seasonal sequences in the future.

In April of 1968, many different preliminary sites were investigated in an effort to locate productive areas. Authorities agree that when studying fungi it is best to search for potentially prolific spots and return to these repeatedly during one or more fruiting seasons. I soon discovered suitable collecting sites which will be described in detail later. As indicated, the sampling technique used in a study of this kind is important. During the period between April 15 and October 31, I visited Kalkaska County on nineteen different occasions, each time checking the same locations. Because my search for spring fungi had been comparatively fruitless in 1968, I checked my sites once in May of 1969.

Techniques for collection and study of higher fungi have been discussed previously (LaRue, 1971).

In addition to identifying the fungi collected, I was interested in learning as much as possible about their ecology. Since hydrogen ion concentration, temperature, and moisture are among the major physical factors influencing fungi (Robinson, 1967), relevent data are included in this study. Light is also an environmental factor which influences the fruiting of fungi. However, the light requirements of fungi are not so critical as those of autotrophs, as they do not depend directly on photosynthesis for a source of nutrition. With this and other variables in mind, I did not consider it feasible to spend the time necessary to measure the incident light when collecting.

With reference to the biotic factors, Smith (1949) states that the richness of fungus flora of a locality varies with the richness of the flora in the other major groups of plants. This accounts for the inclusion of lists of conspicuous plants other than fungi occurring in each habitat involved in this problem.

COLLECTING SITES

Location. All of the collecting sites are in Kalkaska County, which is in the northwestern part of Michigan's Lower Peninsula. I collected in three different areas representing four habitat types: mixed woods on the shore of Pickerel Lake in Cold Springs Township, mixed woods surrounding pot-holes or kettles at Pickerel Lake, conifer woods (plantation) on Sunset Trail in Blue Lake Township, and beech-maple woods in Rapid River Township.

To reach the Pickerel Lake sites, one travels about two miles on Sunset Trail after turning north from county road 612. The area is along the southeast shore of the lake in section 25.

The conifers where collections were made are on Sunset Trail in section 19 about one mile beyond the Pickerel Lake site. The beech-maple woods are approached by turning off U.S. 131 and traveling west about 3.3 miles on Plum Valley Road to Lannin Road. The site is located on the abandoned Lannin School property.

Topography. The land surrounding Pickerel Lake lies about 1,225 feet above sea level with the kettles being 10-15 feet lower. The elevation at the conifer site is 1,250 feet, while that at the Lannin School site is about 950 feet.

Soil. Northern Kalkaska County is in a podzol region. The soil consists mainly of limy materials. Especially in the area near Pickerel, the surface layer is very sandy.

A Beckman pocket pH meter was used to test three soil samples at each collecting site and the water in the two kettles near Pickerel Lake. The following results were obtained on September 1, 1968:

	Pickerel Lake			Conifer Plantation	Lannin School
	Large kettle	Small kettle	Lake Shore		
Soil:	5.0	4.6	4.4	5.0	6.0
	4.8	4.8	6.0	5.6	6.0
	5.2	5.2	5.6	5.4	5.6
Water:	8.4	7.5			

Climate. The total precipitation for 1968 based on data from the Kalkaska weather station was 33.25 inches. The monthly totals of precipitation in inches through October when collection ceased were as follows:

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1.29	2.32	0.66	2.35	2.28	2.54	2.71	1.91	5.12	6.09

The following list shows the annual precipitation total in inches for Kalkaska County from 1951 through 1968.[1]

[1]U.S. Dep. Commerce, Michigan Annual Summary, Vol. 71-82: #13; Vol. 83: #1-10, #13; U.S. Weather Bureau Climatic Summary, Supplement 1951-60: 13.

Year	Rainfall in inches	Year	Rainfall in inches
1951	33.62	1960	33.99
1952	32.17	1961	34.15
1953	32.59	1962	28.22
1954	39.03	1963	29.67
1955	26.23	1964	27.31
1956	34.23	1965	37.76
1957	29.30	1966	29.50
1958	26.44	1967	33.99
1959	34.87	1968	33.25

The average daily temperature recorded at the Grayling station (approximately 20 miles southeast of the collecting sites) for each of the months while collecting was in progress were as follows:

Apr.	May	June	July	Aug.	Sept.	Oct.
46.4	50.8	62.7	67.4	67.2	61.3	49.7

Vegetation. Other than fungi, the following plants were most conspicuous in each of the collecting sites.

PICKEREL LAKE NEAR LAKE SHORE (Mixed woods)

Canopy:
- Angiospermae:
  - *Acer rubrum* L.
  - *Betula papyrifera* Marsh.
  - *Fagus grandifolia* Ehrh.
  - *Populus tremuloides* Michx.
  - *Prunus virginiana* L.
  - *Quercus rubra* L.
- Gymnospermae:
  - *Pinus resinosa* Ait.
  - *Pinus strobus* L.

Ground Cover:
- Angiospermae:
  - *Chrysanthemum leucanthemum* L. var. *pinnatifidum* Lecoq. & Lamotte
  - *Comandra richardsiana* Fern.
  - *Cypripedium acaule* Ait.
  - *Gaultheria procumbens* L.
  - *Hieracium aurantiacum* L.
  - *Maianthemum canadense* Desf.
  - *Monotropa uniflora* L.
  - *Pedicularis canadensis* L.
  - *Vaccinium angustifolium* Ait.
- Filicineae:
  - *Pteridium aquilinum* Kuhn
- Musci:
  - *Brachythecium reflexum* (Web. & Mohr) BSG
  - *Bryum capillare* Hedw.
  - *Campylium chrysophyllum* (Brid.) Lange
  - *Ceratodon purpureus* (Hedw.) Brid.
  - *Dicranum scoparium* Hedw.
  - *Heterophyllium haldanianum* (Grev.) Kindb.
  - *Pleurozium schreberi* (Brid.) Mitt.
  - *Pohlia nutans* (Hedw.) Lindb.
  - *Polytrichum piliferum* Hedw.

PICKEREL LAKE NEAR KETTLES (Mixed woods)

Canopy:
- Angiospermae:
  - *Acer rubrum* L.
  - *Betula papyrifera* Marsh.
  - *Populus tremuloides* Michx.
- Gymnospermae:
  - *Pinus resinosa* Ait.

Ground cover:
- Angiospermae:
  - *Cornus canadensis* L.
  - *Gaultheria procumbens* L.
  - *Impatiens capensis* Meerb.
  - *Maianthemum canadense* Desf.
  - *Mitchella repens* L.
  - *Tiarella cordifolia* L.
  - *Trientalis borealis* Raf.
  - *Vaccinium* sp.
- Filicineae:
  - *Pteridium aquilinum* Kuhn

PICKEREL LAKE NEAR KETTLES (Mixed woods) (cont'd.)

Musci:
Aulacomnium palustre (Hedw.) Schwaegr.
Brachythecium salebrosum (Web. & Mohr) BSG
Dicranum flagellare Hedw.
Dicranum scoparium Hedw.
Heterophyllium haldanianum (Grev.) Kindb.
Mnium cuspidatum Hedw.

CONIFER PLANTATION

Canopy:
Gymnospermae:
Abies balsamea (L.) Mill.
Picea pungens Engelm.
Pinus resinosa Ait.
Pinus strobus L.
Pseudotsuga menziesii (Mirb.) Franco

Ground Cover:
Filicineae:
Pteridium aquilinum Kuhn
Musci:
Brachythecium rutabulum (Hedw.) BSG
Drepanocladus uncinatus (Hedw.) Warnst.
Polytrichum juniperinum Hedw.

LANNIN SCHOOL PROPERTY (Deciduous woods)

Canopy:
Angiospermae:
Acer rubrum L.
Fagus grandifolia Ehr.
Populus balsamifera L.
Prunus serotina Ehrh.
Ulmus rubra Muhl.
Tilia americana L.

Ground Cover:
Angiospermae:
Carex sp.
Claytonia caroliniana Michx.
Dicentra cucullaria (L.) Bernh.
Erythronium americanum Ker.
Fragaria virginiana Duchesne
Hieracium aurantiacum L.
Rubus sp.
Trillium grandiflorum (Michx.) Salisb.
Viola sp.

Filicineae:
Adiantum pedatum L.
Botrychium virginianum Swartz
Dryopteris intermedia Gray
Pteridium aquilinum Kuhn
Musci:
Amblystegium varium (Hedw.) Lindb.
Atrichum angustatum (Brid.) BSG
Brachythecium salebrosum (Web. & Mohr) BSG
Brachythecium velutinum (Hedw.) BSG
Campylium chrysophyllum (Brid.) Lange
Campylium hispidulum (Brid.) Mitt.
Platydictya subtile (Hedw.) Crum
Pylaisiella selwynii (Kindb.) Crum, Steere, & Anders.

LIST OF SPECIES

Families are listed alphabetically, and they are according to descriptions in Smith and Shaffer (1964).

Collection numbers, unless otherwise indicated, are those of LaRue. All specimens cited are deposited in the University of Michigan Herbarium. The first numeral in the date stands for the month and the second for the day. Unless otherwise specified, collections were made in 1968. The following symbols are used to denote type of habitat:

C Conifer plantation
D Deciduous woods
M1 Mixed woods near kettles
M2 Mixed woods near lake

ASCOMYCETES

Geoglossaceae

Geoglossum difforme Fries M1-207 (9/2)
Leotia lubrica Fries M2-164 (8/8), 325 (10/12)

Pezizaceae

Helvella esculenta Fries M2-11 (5/11)
Morchella angusticeps Peck M2-3 (5/4); D-343 (5/11/69)
M. esculenta Fries D-349 (5/11/69)
Morchella sp. (near *deliciosa*) D-346 (5/11/69)
Peziza badia Fries M1-107 (8/1)
Verpa conica Fries D-344 (5/11/69)

Xylariaceae

Daldinia concentrica (Fries) Cesati & DeNotaris D-348 (5/11/69)

BASIDIOMYCETES

Agaricaceae

Agaricus diminutivus Peck C-185 (8/24); D-238, 239 (9/14)

Amanitaceae

Amanita aestivalis Singer M2-145 (8/6)
A. brunnescens Atkinson M2-217 (9/2)
A. citrina S. F. Gray M2-92 (7/19), 322 (10/12)
A. fulva Persoon M1-108 (8/1), 205 (9/2)
A. gemmata (Fries) Gillet D-147 (8/8)
A. muscaria (Fries) S. F. Gray C-86 (7/13), 87 (7/19), 177 (8/9); D-148 (8/8); M1-85 (7/13); M2-292 (9/28)
A. muscaria white variant C-88 (7/19), 267 (9/27)
A. russuloides Peck D-101 (7/20), 103 (7/20), 126 (8/2)
A. virosa Fries D-146 (8/8), 188 (8/24); M1-194 (8/24); M2-245 (9/14)
A. cothurnata group D-125 (8/2)
Close to *A. flavoconia* Atkinson D-67 (7/13); M2-294 (9/28)
Limacella illinita (Fries) Murrill var. *illinita* C-335 (10/26)

Bolbitiaceae

Agrocybe acericola (Peck) Singer M2-23 (6/16)
A. dura (Fries) Singer M2-25 (6/22)

Boletaceae

Boletus affinis Peck M2-182 (8/9)
B. ornatipes Peck M2-138 (8/2), 159 (8/8), 222 (9/13)
B. piperatus Fries M1-206 (9/2)
B. subtomentosus Fries M1-120 (8/1)
B. truncatus (Singer, Snell, & Dick) Pouzar D-278 (9/28)
Leccinum insigne Smith, Thiers, & Watling D-276 (9/28); M1-84 (7/13); M2-219 (9/2)
L. pseudoinsigne Smith & Thiers M2-139 (8/6)
L. scabrum (Fries) S. F. Gray M1-81 (7/13), 173 (8/9); M2-24 (6/22), 142 (8/6), 223 (9/13)
L. snellii Smith, Thiers, & Watling M1-60 (6/29)
Suillus americanus Peck C-178 (8/9); M2-158 (8/8), 227 (9/13), 293 (9/28)
S. intermedius (Smith & Thiers) Smith & Thiers M2-295 (9/28)
S. luteus (Fries) S. F. Gray C-255 (9/27)

Cantharellaceae

Cantharellus cibarius Fries var. *cibarius* M2-143 (8/6)
C. cinnabarinus Schweinitz M2-140 (8/6)

Clavariaceae

Clavaria cinerea Fries C-180 (8/9), 307 (10/11); M2-242 (10/26)
C. pyxidata Fries D-41 (6/29), 100 (7/20); M1-58 (6/29), 114 (8/1); M2-28 (6/22)

Coprinaceae

Coprinus micaceus Fries D-63 (7/13), 345 (5/11/69) and D-229 (9/14), a cespitose variant.
C. radians Fries D-51 (6/29)
Psathyrella kauffmanii Smith D-33 (6/22)
P. obtusata (Fries) Smith D-297 (9/28)
P. subagraria (Atkinson) Smith D-34 (6/22)

Cortinariaceae

Cortinarius obtusus Fries M1-320 (10/12)
C. trivialis S. S. Lange D-285 (9/28); M1-215 (9/2)
Crepidotus mollis Fries D-45 (6/29)
Gymnopilus penetrans (Fries) Murrill M2-169 (8/9)
Inocybe lacera Fries M2-176 (8/9)
Naucoria serrulata Murrill D-248 (9/14)
Pholiota spumosa (Fries) Singer C-338 (10/26)
Rosites caperata (Fries) Karsten M1-313 (10/12)
Tubaria furfuracea (Fries) Gillet D-48 (6/29)

Hygrophoraceae

Hygrophorus acutoconicus (Clements) Smith var. *acutoconicus* D-133a (8/2)
H. borealis Peck f. *borealis* D-242 (9/14), 291 (9/28); M1-318 (10/12)
H. cantharellus (Schweinitz) Fries D-74 (7/13)
H. conicus (Fries) Fries D-77 (7/13), 133b (8/2), 134 (8/2), 236 (9/14), 280 (9/28)
H. flavescens (Kauffman) Smith & Hesler D-29 (6/22), 49 (6/29), 53 (6/29), 72 (7/13), 124 (8/2), 155 (8/8), 237 (9/14), 274 (9/28), 282 (9/28); M1-317 (10/12)
H. laetus (Fries) Fries D-66 (7/13); M1-109 (8/1), 316 (10/12)
H. marginatus Peck var. *marginatus* D-73 (7/13); M1-212 (9/2)
H. marginatus var. *concolor* Smith M1-192 (8/24)
H. nitidus Berkeley and Curtis M1-167 (8/9), 172 (8/9); M2-117 (8/1)
H. pratensis (Fries) Fries D-75 (7/13), 130 (8/2), 273 (9/28); M2-203 (9/2)
H. psittacinus (Fries) Fries var. *psittacinus* D-68 (7/13), 233 (9/14)
H. subviolaceus Peck M1-314 (10/12)

Lycoperdaceae

Calvatia cyathaformis (Bosc) Morgan M2-211 (9/2), 220 (9/13)
C. tatrensis Hollos M2-13 (6/8)
Lycoperdon marginatum Vittadini M2-83 (7/13), 197 (8/24), 218 (9/2)
L. perlatum Persoon C-254 (9/14), 304 (10/11)

Paxillaceae

Paxillus atrotomentosus Fries M1-116 (8/1)

Polyporaceae

Daedalea confragosa Fries M2-174 (8/9)
Favolus alveolaris (Fries) Quélet D-44 (6/29), 106 (7/20); M2-21 (6/15), 26 (6/22)
Fomes fomentarius (Fries) Kickx M2-1 (4/19), 7 (5/4)
Ganoderma applanatum (Persoon ex Wallroth) Gillet D-115 (8/1), 156 (8/8)
Polyporus adustus Fries M2-200 (8/24)
P. albellus Peck D-33 (6/22), 80 (7/13), 93 (7/20)
P. betulinus Fries M1-341 (10/26)
P. betulinus Fries a hydnoid variant M2-2 (4/19)
P. cinnabarinus Fries D-136 (8/2)
P. dichrous Fries D-190 (8/24)
P. elegans Fries D-129 (8/2)
P. fagicola Murrill D-16 (6/15)
P. hirsutus Fries M2-5 (5/4)
P. pargamenus Fries M2-201 (8/24)

P. perennis Fries C-181 (8/9); M2-82 (7/13), 162 (8/8), 199 (8/24)
P. resinosus Fries M2-221 (9/13)
P. squamosus Fries D-38 (6/22)
P. versicolor Fries D-10 (5/4)

Rhodophyllaceae

Claudopus sp. D-234 (9/14)
Entoloma subserrulatum (Peck) Hesler D-235 (9/14)
Leptonia sp. D-154 (8/8); M1-170 (8/9)
Nolanea sp. D-152 (8/8)
N. strictia complex D-9 (8/8)

Russulaceae

Lactarius camphoratus Fries M2-214 (9/2)
L. deceptivus Peck M1-165 (8/9)
L. mutabilis Peck C-268 (9/27)
L. trivialis Fries D-128 (8/2); M2-161 (8/8)
L. vellerius Fries D-157 (8/8); M2-141 (8/6), 195 (8/24)
Russula borealis Kauffman M2-160 (8/8)
R. fallax sensu Kauffman C-297 (10/11); M1-112 (8/1), 216 (9/2); M2-118 (8/1)

Strophariaceae

Naematoloma sublateritium (Fries) Karsten M1-312 (10/12); M2-311 (10/12)

Thelephoraceae

Stereum ostrea (Blume & Nees) Fries D-105 (7/20)
Thelephora caryophyllea Fries M2-175 (8/9)

Tricholomataceae

Armillaria mellea (Fries) Quélet D-277 (9/28); M1-315 (10/12)
Clitocybe adirondackensis (Peck) Saccardo D-243 (9/14)
C. candicans (Fries) Kummer C-262 (9/27), 305 (10/11)
C. candida Bresadola D-230 (9/10)
C. clavipes (Fries) Kummer C-256 (9/27), 258 (9/27), 298 (10/11)
C. gibba (Fries) Kummer C-78 (7/13), 246 (9/14); D-290 (9/28)
C. metachroa (Fries) Kummer C-299 (10/11)
C. subconnexa (Murrill) Bigelow & Smith D-244 (9/14), 284 (9/28)
C. umbonata (Fries) Konrad C-184 (8/24), 257 (9/27), 306 (10/11), 332 (10/26)
Collybia butyracea Fries C-260 (9/27), 261 (9/27), 263 (9/27), 308 (10/11), 331 (10/26)
C. cylindrospora Kauffman D-231 (9/14)
C. dryophila (Fries) Quélet C-259 (9/27); D-18 (6/15), 30 (6/22), 36 (6/22), 37 (6/22), 47 (6/29), 247 (9/14), 281 (9/28); M2-27 (6/22)
C. radicata (Fries) Quélet D-17 (6/15), 19 (6/15), 20 (6/15), 35 (6/22), 52 (6/29), 55 (6/29), 56 (6/29), 69 (7/13), 70 (7/13), 71 (7/13), 95 (7/20), 98 (7/20), 149 (8/8), 150 (8/8), 187 (8/24), 283 (9/28), 286 (9/28)
C. radicata f. *alba* Peck D-54 (6/29), 121 (8/2)
Cystoderma amianthinum (Fries) Fayod C-264 (9/27), 302 (10/11)
Laccaria amethystina (Fries) Cooke C-310 (10/11); M1-111 (8/1)
L. laccata (Fries) Berkeley & Broome C-301 (10/11), 336 (10/26); M1-110 (8/1), 113 (8/1), 191 (8/24), 208 (9/2); M2-119 (8/1), 163 (8/8)
Lentinellus bisus (Quélet) Kühner & Maire D-46 (6/29)
Lyophyllum loricatum (Fries) Kühner M2-296 (9/28)
Marasmius glabellus Peck C-183 (8/24)
M. polyphyllus Peck D-50 (6/29)
M. rotula Fries D-57 (6/29), 232 (9/14)
Melanoleuca alboflavida (Peck) Murrill M2-144 (8/6), 193 (8/24)
Melanoleuca sp. D-272 (9/28)
Mycena alcalina (Fries) Quélet D-12 (5/18), 42 (6/29); M2-340 (10/26)

M. epipterygioides Pearson C-327 (10/26)
M. gracilis (Quélet) Kühner C-39 (6/22)
M. griseoviridis Smith C-326 (10/26)
M latifolia (Peck) Saccardo C-271 (9/27)
M. longipes Murrill M1-324 (10/13)
M. pura (Fries) Quélet C-265 (9/27), 300 (10/11), 329 (10/26)
Omphalia pyxidata (Fries) Quélet D-131 (8/2), 153 (8/8)
Pleurotus ostreatus (Fries) Quélet D-94 (7/20), 122 (8/2), 287 (9/28); M1-22 (6/15), 59 (6/29), 79 (7/13); M2-14 (6/8)
Schizophyllum commune Fries D-104 (7/20), 189 (8/24); M2-6 (5/4)
Tricholoma flavovirens (Fries) Lundell M1-323 (10/12); M2-204 (9/2)
Tricholomopsis platyphylla (Fries) Singer D-31 (6/22), 135 (8/2); M1-62 (6/29)

Volvariaceae

Pleuteus cervinus (Fries) Quélet D-40 (6/22), 249 (9/14)
P. longistriatus Peck D-151 (8/8), 186 (8/24)
Volvariella bombycina (Fries) Singer M2-202 (9/2)

DISCUSSION AND CONCLUSIONS

The flora of saprophytic fungi varies according to the type of substrate available, but the various species may be found in all habitats. A succession of fungi will break down a log, and the particular species fruiting at a given time is determined in part by the physical state of the wood and the species in the area able to attack it. *Coprinus micaceus, Mycena alcalina,* and *Polyporus albellus* collected on this project are all examples of lignicolous fungi. *Mycena pura,* which was found in the conifer woods, is saprophytic growing in humus under either hardwoods or conifers, but mostly the latter.

Other fungi such as many of the Polyporaceae are parasitic to the extent of producing heart rots and untold damage to living trees each year. *Ganoderma applanatum* and *Polyporus betulinus* provide examples of fungi which may be found on either dead trees or dead parts of living trees.

Fungi often form mycorrhiza with the rootlets of green plants. This is considered a symbiotic relationship since both fungus and green plant may benefit from the association. Mycorrhiza are often specific, accounting for the presence of a species of fleshy fungus near a certain species of tree. The Boletaceae in the genus *Suillus* are known to form mycorrhiza with conifers. For example, I repeatedly collected *Suillus americanus* in the vicinity of *Pinus strobus.*

According to Robinson (1967), many fungi are tolerant of a wide range of pH values, from 2.0 to 9.0. Judging by the data from soil samples I tested, the pH of the soil in all four locations was in the 5-6 range, or slightly acidic. Under these circumstances, there would be less competition from soil bacteria since they are less tolerant of acid conditions.

As a rule, fruiting of fungi follows a rise in temperature and moisture. In general, this relationship may be seen from the precipitation and average daily temperature data I have listed. Also it must be noted that certain species such as *Collybia butyracea* and *Clitocybe umbonata* seem to have a special affinity for cool weather, and they are often found at the time of the first snowfall.

TABLE I. Collections made in conifer plantation (C).

April	May	June	July	August	September	October
		Mycena gracilis	Amanita muscaria Amanita muscaria var. alba Clitocybe gibba	Agaricus diminutivus Clavaria cinerea Clitocybe umbonata Marasmius glabellus Polyporus perennis Suillus americanus	Clitocybe candicans Clitocybe clavipes Clitocybe gibba Clitocybe umbonata Collybia butyracea Collybia dryophila Cystoderma amianthinum Lactarius mutabilis Lycoperdon perlatum Mycena latifolia Mycena pura Suillus luteus	Clitocybe candicans Clitocybe clavipes Clitocybe metachroa Clitocybe umbonata Collybia butyracea Cystoderma amianthinum Laccaria amethystina Laccaria laccata Limacella illinata Mycena epipterygiodes Mycena griseoviridis Pholiota spumosa

TABLE II. Collections made in mixed woods near kettles (M1).

April	May	June	July	August	September	October
		Clavaria pyxidata Leccinum snellii Pleurotus ostreatus Tricholomopsis platyphylla	Amanita muscaria Leccinum insigne Leccinum scabrum	Amanita fulva Amanita virosa Boletus subtomentosus Clavaria pyxidata Hygrophorus laetus Hygrophorus nitidus Laccaria amethystina Laccaria laccata Lactarius deceptivus Leccinum scabrum Paxillus atrotomentosus Peziza badia Russula fallax sensu Kauff.	Amanita fulva Boletus piperatus Cortinarius trivialis Geoglossum difforme Hygrophorus marginatus (2 var.)	Armillaria mellea Cortinarius obtusus Hygrophorus borealis Hygrophorus laetus Hygrophorus subviolaceus Mycena longipes Naematoloma sublateritium Polyporus betulinus Rosites caperata Tricholoma flavovirens

TABLE III. Collections made in deciduous woods (D).

April	May	June	July	August	September	October
	Coprinus micaceus	Clavaria pyxidata	Amanita flavoconia	Amanita cothurnata	Agaricus diminutivus	
	Daldinia concentrica	Collybia dryophila	Amanita russuloides	Amanita gemmata	Armillaria mellea	
	Morchella angusticeps	Collybia radicata	Clavaria pyxidata	Amanita muscaria	Boletus truncatus	
	Morchella deliciosa	Coprinus radians	Collybia radicata	Amanita virosa	Claudopus sericellus	
	Morchella esculenta	Crepidotus mollis	Coprinus micaceus	Collybia radicata	Clitocybe candida	
	Polyporus versicolor	Favolus alveolaris	Hygrophorus cantharellus	Ganoderma applanatus	Clitocybe gibba	
	Verpa conica	Hygrophorus flavescens	Hygrophorus conicus	Hygrophorus acuticonicus	Collybia cylindrospora	
	Mycena alcalina	Lentinellus bisus	Hygrophorus flavescens	Hygrophorus conicus	Collybia dryophila	
		Marasmius polyphyllus	Hygrophorus laetus	Hygrophorus flavescens	Collybia radicata	
		Marasmius rotula	Hygrophorus marginatus	Hygrophorus pratensis	Coprinus micaceus	
		Pleuteus cervinus	Hygrophorus pratensis	Lactarius trivialis	Cortinarius trivialis	
		Polyporus albellus	Hygrophorus psitticinus	Lactarius vellereus	Entoloma subserrulatus	
		Polyporus fagicola	Pleurotus ostreatus	Leptonia sp.	Hygrophorus conicus	
		Polyporus squamosus	Polyporus albellus	Omphalia pyxidata	Hygrophorus flavescens	
		Psathyrella kauffmanii	Schizophyllum commune	Pleuteus longistriatus	Hygrophorus pratensis	
		Tricholomopsis platyphylla	Stereum ostrea	Polyporus cinnabarinus	Hygrophorus psitticinus	
		Tubaria furfuracea		Polyporus dichrous	Leccinum insigne	
				Polyporus elegans	Lepista subconnexa	
				Schizophyllum commune	Marasmius rotula	
				Tricholomopsis platyphylla	Melanoleuca sp.	
					Pleurotus ostreatus	
					Pleuteus cervinus	
					Psathyrella obtusata	

TABLE IV. Collections made in mixed woods on lake shore (M2).

April	May	June	July	August	September	October
Fomes fomentarius	Fomes fomentarius	Agrocybe acericola	Amanita citrina	Amanita aestivalis	Amanita brunnescens	Amanita citrina
Polyporus betulinus	Helvella esculenta	Agrocybe dura	Lycoperdon margi-natum	Boletus affinis	Amanita flavoconia	Clavaria cinerea
	Morchella angusticeps	Calvatia tatrensis	Polyporus perennis	Boletus ornatipes	Amanita muscaria	Leotia lubrica
	Polyporus hirsutus	Clavaria pyxidata		Cantharellus cibarius	Amanita virosa	Mycena alcalina
	Schizophyllum commune	Collybia dryophila		Cantharellus cinnabarinus	Boletus ornatipes	Naematoloma sublateritium
		Favolus alveolaris		Daedalea confragosa	Calvatia cyathaformis	
		Leccinum scabrum		Gymnopilus penetrans	Hygrophorus pratensis	
		Pleurotus ostreatus		Hygrophorus nitidus	Lactarius camphoratus	
				Inocybe lacera	Leccinum insigne	
				Laccaria laccata	Leccinum scabrum	
				Lactarius trivialis	Lycoperdon marginatum	
				Lactarius vellerius	Lyophyllum loricatum	
				Leccinum pseudoinsigne	Polyporus resinosus	
				Leccinum scabrum	Suillus americanus	
				Leotia lubrica	Suillus intermedius	
				Lycoperdon marginatum	Tricholoma flavovirens	
				Melanoleuca alboflavida	Volvariella bombycina	
				Polyporus adustus		
				Polyporus pargamenus		
				Polyporus perennis		
				Russula borealis		
				Russula fallax sensu Kauff.		
				Suillus americanus		
				Thelephora caryophyllea		

When comparing Tables I - IV showing the fruiting sequence in the four different habitats, one notices that there was little activity during the month of July. In all except the conifer plantation, there was an active fruiting period prior to July followed by a rest period; then fruiting resumed in August, and extended into the fall season. The data on rainfall and temperature do not apparently account for the dearth of carpophores in July.

For the most part, the species represented in August were different from those fruiting in June. In the deciduous woods, the outstanding exceptions were *Hygrophorus flavescens* and *Collybia radicata,* both of which were abundant and spanned the period of June through September.

From the original 349 collections made, I was able to identify 144 taxa representing 21 families, 62 genera, and 141 species. *Collybia radicata* was collected abundantly in its usual variable state including the form *alba.* Two varieties for each of the following species were collected: *Amanita muscaria, Coprinus micaceus,* and *Hygrophorus marginatus.* The family represented by the largest number of genera is Tricholomataceae. *Polyporus* sensu lato was the genus with the most species, but is considered a family by many current mycologists.

Many other conclusions may be drawn from the data. First, when I started to collect in April, 1968, polypores and a very few Ascomycetes were the only fungi available. It was not until the spring of 1969 that I finally found several species of the larger Ascomycetes. Contrasted with the Ascomycetes, the boletes and puffballs appeared later in the season and became abundant after August 1.

The fact that there were no puffballs found at the beech-maple woods may have been due to the fact that conditions were not conducive to their growth during the period under study. On the other hand, *Amanita muscaria* grew in all habitats under consideration showing its adaptability to different conditions.

In addition to many species common to Michigan, I also collected a species not formerly recorded from this state, *Calvatia tatrensis,* previously collected in Wyoming by Dr. Smith.

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I wish to thank Dr. Alexander H. Smith for his generous help and encouragement during the course of this problem including checking the identifications and helping with the nomenclature. I am also grateful to Mr. Dennis Jackson for his assistance in the preparation of my thesis, and to Dr. Herbert Caswell, Dr. Bert Johnson, and Mr. Joseph Ammirati, Jr., for their advice and critical reading of my original manuscript.

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LaRue, Jane I. 1971. An introduction to the collection and study of higher fungi. Mich. Bot. 10: 89-93.

Smith, A. H. 1949. Mushrooms in Their Natural Habitats. Swayer's, Portland, Ore. 626 pp.

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Nature education feature --

SUMMER FIELD KEY TO SOME COMMON MICHIGAN TREES

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This key to some of our native Michigan trees is intended to be a "first" tree key for students new to the study of seed plant identification. A similar key for trees in the winter condition appeared earlier (Wells, J. R., 1970. Winter Field Key to Some Trees Common in Michigan. Mich. Bot. 9: 55-58). The species included are among our most widespread and easily-identifiable woody plants. For the sake of brevity I have attempted to eliminate common introduced species and native rarities, as well as certain species which are considered borderline between large shrubs and small trees.

The keys are non-technical insofar as possible; a few "good" characters are chosen in lieu of a wider selection of alternate choices which may not be as readily apparent to the novice or are not so obvious throughout the growing season.

Any of the three references discussed below may be considered among the first supplements for further tree study. A short discussion of each points out its merits in helping guide the beginner toward a more comprehensive knowledge of this most conspicuous phase of plant life in Michigan.

Braun, E. Lucy. 1961. *The Woody Plants of Ohio.* 362 pp. Ohio State University Press, Columbus (out of print). Reprinted 1969 by Stechert-Hafner, 31 E. 10th St., New York, N. Y. 10003. Clothbound, $16.50.

Although Michigan has more tree species than Ohio, this reference is of value for Michigan tree science because of the many species common to both areas, particularly in southern Michigan. The line drawings of twigs in the winter condition are among the best available and serve well to complement equally lucid illustrations of leaves, flowers, and fruits. Keys to trees in the winter condition are provided, as well as a set of keys based on characters found in the other seasons. The nomenclature follows *Gray's Manual of Botany,* 8th ed. (1950). The Ohio distribution maps help to show what may be expected in adjacent southern Michigan.

Otis, Charles H. 1931. *Michigan Trees.* 362 pp. University of Michigan Press, Ann Arbor, Mich. 48106. Paperbound, $2.75.

Now in its 17th printing, this handsome little volume is the best comprehensive reference to Michigan trees. Two sets of keys are provided, one for trees in leaf and one for trees in the winter condition. The line drawings of leaves and winter twigs are somewhat inferior to those of Braun's *Woody Plants.* A glossary is preceded by a 54-page section of somewhat questionable field value which treats of wood characters as viewed in cross, radial, and tangential section. Both keys and line drawings are contained in this latter section.

Smith, Norman F. 1952. *Michigan Trees Worth Knowing.* 60 pp. Forestry Division, Mich. Dept. of Conservation, Lansing, Mich. (3rd ed. 1961, out of print). Reprinted 1970, Hillsdale Educational Publishers, Inc., Hillsdale, Mich. Paperbound, $2.50.

The 57 species listed in this booklet are arranged alphabetically by common name—no keys. One species is described per page and each is illustrated by good quality black and white photographs depicting leaf, fruit, habit of plant, and bark characteristics. The data pertaining to each species include not only the identifying characteristics but such things as estimated volume in the state and historical notes. A short glossary and illustrations pertaining to leaf terminology are provided.

1. Leaves linear or scale-like, less than 2.7 mm wide 2
1. Leaves with blades expanded, wider than 2.7 mm 11

2. Leaves scale-like or tapering to a sharp point, less than 13 mm long 3
2. Leaves needle-like, more than 13 mm long 4

3. Leaves scale-like and branchlets flattened . . . . . *Thuja occidentalis* (white cedar)
3. Leaves awl-shaped, tapering to a sharp point or, if scale-like, not borne on flattened branchlets . . . . . *Juniperus virginiana* (red cedar)

4. Leaves borne singly on branches 5
4. Leaves borne in clusters 8

5. Leaves flattened in cross section 6
5. Leaves square in cross section 7

6. Leaves of 2 lengths, those along upper side of twig shorter; leaf bases persistent as stalks on twigs after leaf fall; cones hanging . . . *Tsuga canadensis* (hemlock)
6. Leaves approximately of equal length, leaving a round scar and no persistent base; cones erect . . . . . *Abies balsamea* (balsam fir)

7. Twigs and buds minutely hairy; cones less than 3 cm long . . . . . *Picea mariana* (black spruce)
7. Twigs and buds without hairs; cones 3-6 cm long . . . . . *Picea glauca* (white spruce)

8. Leaves in clusters of more than 5 . . . . . *Larix laricina* (larch, tamarack)
8. Leaves in clusters of 5 or fewer *Pinus* (pine) 9

9. Leaves 5 in a bundle . . . . . *Pinus strobus* (white pine)
9. Leaves 2 in a bundle 10

10. Leaves 1.5-3 cm long . . . . . *Pinus banksiana* (Jack pine)
10. Leaves 8-15 cm long . . . . . *Pinus resinosa* (red pine)

11. Trees with thorns 12
11. Trees without thorns 17

12. Leaves simple 13
12. Leaves pinnately compound 16

13. Leaf margins toothless; sap milky . . . . . *Maclura pomifera* (osage-orange)
13. Leaf margins with teeth; sap not milky 14

14. Most thorns without buds along their length; leaves usually lobed . . . . . *Crataegus* spp. (hawthorn)
14. Thorns bearing buds along their length; leaves with or without lobes 15

15. Terminal bud absent; leaves unlobed . . . . . *Prunus americana* (wild plum)
15. Terminal bud present; leaves sometimes lobed . . . . . *Pyrus coronaria* (wild crabapple)

16. Thorns unbranched, in pairs opposite leaves or leaf scars . . . . . *Robinia pseudoacacia* (black locust)
16. Thorns often branched, scattered along stem . *Gleditsia triacanthos* (honey locust)

17. Leaves compound 18
17. Leaves simple 33

18. Leaves palmately compound; leaflets 5 . . . . . *Aesculus glabra* (Ohio buckeye)
18. Leaves pinnately compound 19

19. Leaves opposite 20
19. Leaves alternate 23

20. Leaflets 3-7, coarsely toothed near apex. . . . . *Acer negundo* (box-elder)
20. Leaflets 7-11, finely toothed or toothless *Fraxinus* (ash) 21

21. Leaflets sessile; fruit lacking a calyx . . . . . *Fraxinus nigra* (black ash)
21. Leaflets stalked; fruit bearing a calyx 22

22. Leaflets and twigs not hairy, leaflets whitened beneath, their stalks not winged . . . . . *Fraxinus americana* (white ash)
22. Leaflets and twigs often minutely hairy, leaflets green beneath, their stalks winged nearly to base . . . . . *Fraxinus pennsylvanica* (red ash)

23. Leaflets with teeth only at base, each tooth bearing a gland below . . . . . *Ailanthus altissima* (tree of heaven)
23. Leaflets toothless or with teeth near apex, glandless 24

24. Stipules or their scars present; vein scars 3 or 5 . . . . . *Sorbus americana* (mountain ash)
24. Stipules and their scars absent; vein scars more than 5 25

25. Lateral buds at least partially concealed by leaf stalks *Rhus* (sumac) 26
25. Lateral buds totally exposed 28

26. Leaflets entire (POISON) . . . . . *Rhus vernix* (poison sumac)
26. Leaflets toothed 27

27. Stems densely hairy, round in cross section . . . . . *Rhus typhina* (staghorn sumac)
27. Stems smooth or nearly so, often 3-angled . . . . . *Rhus glabra* (smooth sumac)

28. Middle leaflets the largest; pith circular in cross section, transversely partitioned *Juglans* (walnut) 29
28. Terminal leaflets the largest; pith angled in cross section but not partitioned *Carya* (hickory) 30

29. Pith cocoa-colored; a ridge of hairs above upper margin of leaf scar; nuts elongate, laterally flattened . . . . . *Juglans cinerea* (butternut)
29. Pith tan; leaf scar without ridge of hairs; nuts spherical . . . *Juglans nigra* (black walnut)

30. Terminal buds orange, bud scales 6 or fewer, meeting along their margins . . . . . *Carya cordiformis* (bitternut hickory)
30. Terminal buds not orange, bud scales 6 or more, overlapping 31

31. Leaflets usually 7-9, their lower surface with tufts of small hairs; fruits 4-6 cm thick, husk 6-11 mm thick . . . . . *Carya laciniosa* (big shellbark hickory)
31. Leaflets usually 5, their lower surface smooth or lacking tufts of hairs; fruits smaller, husk thinner 32

32. Tufts of hairs present at leaflet margin near each tooth; bark peeling longitudinally in strips; nut angled from top to base . . . *Carya ovata* (shagbark hickory)
32. Tufts of hairs at leaflet margin absent; bark often with ridges and furrows but not peeling in strips; nut 4-angled only above middle . . . . . *Carya glabra* (pignut hickory)

33. Leaves whorled or nearly so, 3 at a node . . . . . *Catalpa speciosa* (northern catalpa)
33. Leaves opposite or alternate 34

34. Leaves opposite 35
34. Leaves alternate 39

35. Leaves not lobed; margins without distinct teeth . *Cornus florida* (flowering dogwood)
35. Leaves lobed; margins toothed or both lobed and toothed *Acer* (maple) 36

36. Buds, twigs, and mature leaves hairy beneath . . *Acer spicatum* (mountain maple)
36. Buds, twigs, and mature leaves not all hairy 37

37. Leaves green beneath; middle lobe with about 3-5 large teeth . . . . . *Acer saccharum* (sugar maple)
37. Leaves whitened beneath; their middle lobe with more than 3 teeth 38

38. Middle lobe of leaf broadest at its base . . . . . *Acer rubrum* (red maple)
38. Middle lobe of leaf broadest near its middle . . . . *Acer saccharinum* (silver maple)

39. Buds clustered at tips of twigs *Quercus* (oak) 40
39. Buds not clustered at tips of twigs 44

40. Lobes rounded, without bristle tips 41
40. Lobes pointed, ending in bristle tips 42

41. Lower leaf surface minutely hairy; the middle pair of sinuses often extending to near the midvein; acorn cup fringed around the margin . *Quercus macrocarpa* (bur oak)
41. Lower leaf surface without hairs; the middle pair of sinuses about as deep as those above or below; acorn cup lacking fringed margin . . . . . *Quercus alba* (white oak)

42. Sinuses usually extending less than halfway to midvein . . . . . *Quercus borealis* (northern red oak)
42. Sinuses extending halfway or usually more to midvein 43

43. Mature leaves hairy beneath; terminal buds 5-angled, hairy . . . . . *Quercus velutina* (black oak)
43. Mature leaves hairy only in the vein-axils beneath; terminal buds not 5-angled, without hairs or only slightly hairy. . . . . *Quercus palustris* (pin oak)

44. Axillary buds covered by leaf stalk bases; bark peeling in large thin plates . . . . . *Platanus occidentalis* (sycamore)
44. Axillary buds not hidden by leaf stalk bases; bark tight, or not peeling in large plates 45

45. Leaves symmetrically or asymmetrically heart-shaped, the two basal lobes equal in size and margins without teeth, or leaves with one lobe narrower and shorter than the other and margins toothed 46
45. Leaves not heart-shaped 47

46. Leaves hairless below, margins toothless, basal lobes of equal size . . . . . *Cercis canadensis* (redbud)
46. Leaves with tufts of hairs in axils of veins below, margins toothed, basal lobes of unequal size . . . . . *Tilia americana* (American basswood)

47. Leaves not lobed 50
47. Leaves all lobed or with both lobed and unlobed leaves on the same tree 48

48. Lobed and unlobed leaves on the same tree 49
48. Lobed leaves only on the tree; the tip broadly notched or nearly straight across; twigs encircled by a narrow scar at base of leaf stalk . . . . . *Liriodendron tulipifera* (tulip tree)

49. Leaf margins toothed; sap milky . . . . . *Morus rubra* (red mulberry)
49. Leaf margins toothless; sap not milky but aromatic . . . . *Sassafras albidum* (sassafras)

50. Leaf bases asymmetrical 51
50. Leaf bases symmetrical 54

51. Leaf margins wavy, the teeth rounded . . . . . *Hamamelis virginiana* (witch hazel)
51. Leaf margins with pointed teeth 52

52. Leaves with 3 prominent veins from base; pith chambered . . . . . *Celtis occidentalis* (hackberry)
52. Leaves distinctly pinnately veined; pith continuous *Ulmus* (elm) 53

53. Twigs and upper leaf surfaces rough-hairy, densely hairy beneath; buds with rusty hairs; fruits rounded, with hairless margins . . . . . *Ulmus rubra* (slippery elm)
53. Twigs and leaf surfaces smooth or leaves somewhat roughened above, lower surface hairless or nearly so; buds smooth or only minutely hairy; fruits notched at tip, with hairy margins . . . . . *Ulmus americana* (American elm)

54. Bud scales 1 . . . . . *Salix* spp. (willow)
54. Bud scales more than 1 55

55. Leaves mostly 15-25 cm long, their margins toothless ..... *Asimina triloba* (pawpaw)
55. Leaves mostly smaller, the margins toothed 56

56. Leaf stalks flattened laterally *Populus* (poplar) 57
56. Leaf stalks circular in cross section 59

57. Leaf teeth large, fewer than 25 ..... *Populus grandidentata* (bigtooth aspen)
57. Leaf teeth smaller, more than 25 per leaf 58

58. Leaves 7 cm long or longer, their bases straight, perpendicular to leaf stalk; teeth curved inward and thickened ..... *Populus deltoides* (cottonwood)
58. Leaves shorter than 7 cm, bases not perpendicular to leaf stalk, teeth not curved inward and thickened ..... *Populus tremuloides* (quaking aspen)

59. Leaves fragrant when crushed; buds gummy .... *Populus balsamifera* (balsam poplar)
59. Leaves not fragrant nor buds gummy 60

60. Bark smooth, tightly adhering to the gray stem; leaf teeth pointed 61
60. Bark roughened or not gray; leaf teeth pointed or rounded 62

61. Older stems fluted, giving a muscular appearance; lateral veins averaging less than 1 per tooth; buds less than 1 cm long ..... *Carpinus caroliniana* (ironwood)
61. Older stems circular in cross section; 1 lateral vein per tooth; buds at least 1 cm long ..... *Fagus grandifolia* (beech)

62. Lateral buds borne on short stalks ..... *Alnus rugosa* (speckled alder)
62. Lateral buds not stalked 63

63. Leaves glandular at base of blade or summit of leaf stalk *Prunus* (cherry) 64
63. Leaves not glandular at base 66

64. Leaf margin with sharp, ascending teeth ..... *Prunus virginiana* (choke cherry)
64. Leaf margin with blunt or incurved teeth 65

65. Lower leaf surface with a row of hairs on each side of midvein ..... *Prunus serotina* (wild black cherry)
65. Lower leaf surface lacking hairs ..... *Prunus pensylvanica* (pin cherry)

66. Bark peeling in horizontal sheets, with distinct horizontal markings (raised lenticels) *Betula* (birch) 67
66. Bark smooth, longitudinally striped, or splitting into thin narrow plates (scaly) 68

67. Bark of trunk white ..... *Betula papyrifera* (paper birch)
67. Bark of trunk yellowish-brown ..... *Betula alleghaniensis* (yellow birch)

68. Bark often longitudinally striped; twigs smooth; lateral veins curved near leaf margin ..... *Amelanchier* spp. (serviceberry)
68. Bark splitting into thin narrow plates; twigs often with glandular hairs; lateral veins straight to leaf margin ..... *Ostrya virginiana* (hop-hornbeam)

News of Botanists and Botany

Fred W. Case, well known to Michigan botanists as a long-time member of the Botanical Club as well as for his book, *Orchids of the Western Great Lakes Region,* published by Cranbrook, was honored on April 16 when he was presented with an award as Michigan's outstanding biology teacher–the highest honor a high school biology teacher can receive in the state. He is chairman of the science department at Arthur Hill High School in Saginaw. Receipt of the state award means he will now be considered for the national award, sponsored by the National Association of Biology Teachers. ..... Eric Bourdo, dean of the School of Forestry at Michigan Technological University, has been presented with the 1971 distinguished service award by the Wisconsin-Michigan Section of the Society of American Foresters.

* * * * * *

Just as the previous issue of *The Michigan Botanist* was being mailed, with its account (p. 94) of the Cyrus H. McCormick Experimental Forest in the Upper Peninsula, there came word from the U. S. Forest Service of the designation of the McCormick Research Natural Area in this Forest. The Natural Area consists of 3,675 acres in the northeast portion of the tract and is the largest Research Natural Area on Federal land east of the Mississippi. It includes the best timber and some of the most rugged and scenic parts of the McCormick Experimental Forest.

* * * * * *

At a meeting on the Michigan State University campus in East Lansing on April 6, 1971, the newly formed Red Cedar Chapter, Michigan Botanical Club, received its charter and elected officers. About 150 persons attended, necessitating a move to a larger room. The charter, printed in Old English, was prepared by Mrs. Duane Kalin of Chippewa Lake, Michigan. State membership chairman Dee LaBatt made the presentation. Officers elected for two-year terms are Dr. Harold Davidson, president; Dr. William G. Fields, vice-president; Mrs. James W. Hanover, secretary; and Mr. Jesse L. Saylor, treasurer. Temporary officers during organization of the chapter have been Dr. John H. Beaman, chairman; Dr. William B. Drew, vice chairman; and Jesse L. Saylor, secretary-treasurer. The program for the meeting was provided by Dr. Alexander H. Smith, speaking on "Spring Mushrooms, Edible and Otherwise." On April 6, the Red Cedar Chapter had attained a membership of 115.

Pictured in the charter presentation, below, are (left to right) John Beaman, temporary chairman; Mrs. Duane Kalin, charter artist; and Dee LaBatt, state membership chairman of the Botanical Club. (Photo by Dr. Bert E. O'Beirne.)

Editorial Notes

The March number (Vol. 10, No. 2) was mailed March 19, 1971.

We are grateful for the response to our plea for certain back issues needed to complete additional sets for new institutional (and other) subscribers who may wish them. Please note that it is those issues listed below (not *all* back issues) which are desired. For economy, they should be mailed at the transient second-class rate, not as first class mail!

Vol. 1, No. 1 & No. 2	Vol. 5, No. 1
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Vol. 4, No. 3	Vol. 9, No. 3

Good black and white photos suitable for use as cover pictures are always desired and may be submitted to the editor at any time. They should be of striking quality, have some botanical content, and be taken in the Great Lakes region. A modest payment of $5.00 is made for photos used.

DISTRIBUTION OF *THE MICHIGAN BOTANIST*

Readers may be interested in a summary of the circulation of this journal, which is worldwide, although concentrated in the Great Lakes region. Members of the Michigan Botanical Club receive a subscription as one of the privileges of membership, accounting for about 575 subscriptions at present. 144 individuals and 138 institutions subscribe directly, as non-members, through our business and circulation manager. The University of Michigan General Library has a standing order for 90 copies of each issue, which are distributed by the Library in exchange for other periodicals, chiefly foreign (23 of these are not yet in actual use as exchanges). These figures give a total paid circulation of 947.

Most but by no means all of the Botanical Club members' copies go to Michigan addresses. Of the 144 direct *personal* subscriptions, 24 are foreign (chiefly Canada), 32 are Michigan, and 88 go to other states. *Institutional* circulation (including the 67 thus far scheduled on exchange by the Library) is as follows:

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Exchanges and direct (non-member) subscriptions–both institutional and personal –total 40 to Canada, 74 other foreign, 74 to Michigan, and 161 to other states, plus 23 held by the University Library for future exchanges. These 372 subscriptions, plus approximately 575 through members' dues, total the 947 figure cited above.

CONTENTS

The Genus *Aster* in Michigan. I.
Distribution of the Species
Paul Van Faasen 99

Two New Species of *Hypomyces* from Michigan
Clark T. Rogerson & Samuel J. Mazzer 107

Changing Abundance of Two Species of *Linum* in
Eastern North America
C. M. Rogers 113

Publication of Interest 116

Observations on Some Aquatic Plants in Northwestern Minnesota
John W. Thieret 117

A Sample of the Seasonal Occurrence of Higher Fungi
in Kalkaska County, Michigan
Jane I. LaRue 125

Nature Education Feature—
Summer Field Key to Some Common Michigan Trees
James R. Wells 137

News of Botanists and Botany 142

Editorial Notes 143

(On the cover: Lichens (chiefly Loboria pulmonaria*)
on tree trunk near Craig Lake, Baraga County, Michigan.
Photo by John S. Russell, May 27, 1968.)*

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors should be guided by "Information for Authors" (Vol. 9, p. 62; copies available from the editor).

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THE FLORA OF ROCK COUNTY, WISCONSIN

Lytton J. Musselman, Theodore S. Cochrane,
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County floras serve many interests: they assist local amateurs to identify the plants growing in their regions; they furnish detailed information which professional botanists can use in phytogeographical and ecological comparisons with adjoining counties and more distant regions; and they document the lamentable extinction of native plants as well as the ever-increasing spread of adventives and weeds. Most importantly, local floras can stimulate interest in the conservation of a livable world. Man's demographic and technologic revolutions are as evident in Rock County as they are anywhere else. Expanding urbanization and agriculture during the past few years alone have been responsible for the destruction of several choice sites. Unless many and diverse refuges are set aside immediately as recreation areas, hiking trail systems, county parks, and scientific preserves, future generations will be forced to envision native plants as mere words or pictures in a book.

INTRODUCTION

The major part of this work is a critical enumeration of all species of native and introduced vascular plants that are known to grow or to have grown without cultivation in Rock County, Wisconsin. A preliminary list was compiled from an examination of all available material preserved in the herbaria of the University of Wisconsin (WIS), University of Wisconsin, Rock County Campus (ULJ), University of Wisconsin, Milwaukee (UWM), Milwaukee Public Museum (MIL), Beloit College, and that of E. W. Fell. Collections made in the area from 1963 to 1970 by the authors have been deposited in WIS and ULJ.

HISTORY OF BOTANICAL EXPLORATION

The first resident plant collector in Rock County was Thomas McElHenry, a tailor from New York, who came to Beloit in 1838. He corresponded with the eminent Wisconsin scientist Increase A. Lapham, who cited in his 1849 paper on the flora of Wisconsin 16 specimens which were sent to him by McElHenry. One of the most prolific early plant collectors was Samuel H. Watson, an immigrant from England. As a boy he collected in the vicinity of his father's farm near Fulton, and near Janesville, in the late

[1]Present address: Department of Botany and North Carolina Botanical Garden, University of North Carolina, Chapel Hill.

1850's. Thomas J. Hale, an acquaintance of Watson's and a field assistant in the state geological survey, collected in the county from 1860 to 1862. Some Hale and Watson specimens are at Milton College (MCW), the University of Wisconsin, Rock County Campus, and the University of Wisconsin.

The first active botanist at Beloit College was physician-chemist Stephen Pearl Lathrop, who later became chancellor of the University of Wisconsin. Like McElHenry, Lathrop sent specimens to Lapham which Lapham cited in his 1852 paper. Several of Lathrop's specimens survive in the Beloit College herbarium, but the collections cited by Lapham were apparently destroyed in the 1884 fire which burned the original University of Wisconsin herbarium.

Goodwin Deloss Swezey, a native of Rockford, Illinois, and a graduate of Beloit College, came to the college to teach natural history and other subjects. Swezey was on the staff at the same time as the well-known geologist Thomas C. Chamberlin, and he prepared a catalogue of Wisconsin vascular plants for Chamberlin's work on the geology of the state. Several of Swezey's specimens are preserved in the herbaria at Beloit and Madison. Nurseryman Henry L. Skavlem collected near Janesville in the 1880's, and many of his specimens are in the herbarium of the University of Wisconsin at Madison. G. B. Olds, a resident of Beloit and perhaps a graduate of the college there, did some collecting in various parts of Rock County in the 1890's.

Albert Rogers Crandall was associated with Milton College first as a student and later as a professor of natural history and physiology from 1903 to 1918. His collections from the northeast part of the county are in the Milton College herbarium. Harry V. Truman collected many specimens in the Beloit vicinity in the 1930's. Egbert W. Fell, a Rockford physician, did extensive collecting in southern Rock County during the 1950's. His specimens are at Madison.

Botanists from the Milwaukee Public Museum, including Albert M. Fuller and Emil P. Kruschke, have made collections in Rock County. Among the many botanists from the University of Wisconsin at Madison who have collected in Rock County are L. S. Cheney, Rodney True, J. J. Davis, Henry C. Greene, Norman C. Fassett, Hugh H. Iltis, and their students. J. T. Curtis and his students performed several ecological studies on prairies (Green, 1950) and lowland woods in the county.

LOCATION AND EXTENT OF AREA

Rock County, which is centrally located in extreme southern Wisconsin, adjacent to Winnebago County, Illinois, lies just above 42°30′ North Latitude, and it is bisected by the meridian 89°05′ West Longitude. The county is rectangular in shape, being about twenty-nine miles from east to west and twenty-four miles wide. Its twenty townships comprise an area of about 716 square miles, or 462,720 acres.

TOPOGRAPHY, GLACIAL HISTORY, AND DRAINAGE

The powerful furrowing and leveling performed by the advancing and retreating Pleistocene ice sheets left all of Rock County with a moderately

smooth topography. The last major advance of the ice, the Wisconsin, descended only as far south as a line extending from the northwest corner of the county to the middle of the eastern boundary. Its position is marked by the Cary terminal moraine (Map 2), which rises to 250 feet above the outwash sand and gravel plains associated with its formation.

That portion of the county which lies south of the outwash plain and west of the Rock River belongs to the physiographic province called the Western Upland (Martin, 1965). Southwestern Rock County is transfused with a cuesta developed on a belt of Ordovician Galena dolomite overlying St. Peter sandstone. Since the old pre-Wisconsin drift material is quite shallow, the configuration of the land is determined by the underlying rock, which is frequently exposed on hills.

The remainder of the county occupies the Eastern Ridges and Lowlands and can be subdivided into three distinct topographic regions. The late-Wisconsin drift region north of the terminal moraine is a rolling surface interrupted by kettle basins, gravel knolls, undrained wetlands, and ridges. The pre-Wisconsin drift region east of Rock River and south of Turtle Creek, a smooth to gently undulating loess-mantled surface, has a covering of drift ranging from 10 to more than 100 feet thick. The Rock River valley fill region is an unpitted outwash plain consisting of material which is nearly 400 feet thick where it overlies the valley of a river which existed before the outwash event (cf. LeRoux, 1963).

Rock County lies within the drainage basin of the Rock River, a tributary of the Mississippi River. Major tributaries include the Sugar River, Yahara River, Turtle Creek, Bass Creek, and Coon Creek, all of which have very gentle gradients and meander through substantial areas of floodplain. Smaller creeks furnish favorable drainage throughout the county except in the north and northeast, where a number of small lakes and marshes remain undrained.

SOILS

The soils of Rock County are gray-brown silt loams developed on calcareous drift. These silt-clay mixtures have been classified into 11 series, including 22 types (Whitson *et al.*, 1922). Revised major associations are Fayette–Dubuque, Parr–Corwin–Warsaw, Fox–Rodman, and Dodge–McHenry–Elba.

The northern third of the area consists of the light brown rolling loams of the glaciated uplands. The dark prairie loams are found largely in the southeast and west-central portions of pre-Wisconsin drift. Dark brown and black level loams associated with outwash plains and poorly drained uplands are extensive, while the deep black silty loams and peats of low ground are restricted to the southeast and southwest corners and several other small areas. Small areas of shallow sandy loams in Avon and Newark Townships support well-drained woodlands.

CLIMATE

The climate of Rock County is humid continental; that is, the temperate summers are warm and humid, and the cold winters are long and snowy. Average annual precipitation is 32 inches, 8% of which falls as snow. The greatest precipitation occurs from May to September, with 60% falling during the growing season. During December, January, and February, the precipitation is less than 2 inches water equivalent per month. The mean January temperature is about 19° F, July 73°, and the annual average 49°. Day-length ranges from 9^h7^m in December to 15^h20^m in June. Beloit records (Wisconsin Crop Reporting Service, 1961) report the average date of the last killing frost as 1 May, while the first fall freeze is 13 October. Therefore the growing season is normally 165 days long, but it averages 155 in the southwest part of the county and over 170 in the central valley.

THE PRESETTLEMENT VEGETATION OF ROCK COUNTY, WISCONSIN

Robert K. Peet
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When Rock County was originally surveyed in the early 1830's, it appeared largely as a land of grass. The familiar oak woods of today were virtually non-existent, the only true forests being found on the floodplains of the larger rivers. A savanna vegetation of prairie grasses and open-grown oaks covered roughly one half of the county while much of the remaining land was true prairie. The wetter areas supported a variety of vegetational formations, including frequent sedge meadows and occasional marshes, shrub-carrs, and three sphagnum bogs.

The true prairies of the county were concentrated in several large blocks. The largest, the Rock Prairie, extended from the Rock River east into Walworth County, covering the flat glacial outwash plains south of the Johnstown moraine. A sod of *Andropogon gerardii* and *Sorghastrum nutans* grew to a height of 8 feet and had a root depth of twice that on these deep-soiled upland prairies, which today provide the state with its richest farmlands. Shorter bunch grasses such as *Andropogon scoparius* and *Bouteloua curtipendula* dominated the more xeric sites, usually shallow-soiled hill crests. The rank growth of *Andropogon gerardii* and *Spartina pectinata* found on the low prairies graded into *Calamagrostis canadensis* and *Leersia oryzoides* on wetter sites. More frequently, however, the lowlands were dominated by tussock-forming sedges such as *Carex stricta.* Wet prairies and sedge meadows, located mostly in the townships of Avon, Newark, Plymouth, and Spring Valley, comprised about 8% of the land (Map 1).

The best known of the prairie plants are the showy herbaceous species. The mesic upland prairies, while now an extinct community type because of the fertility of their soils, originally supported a spectacular growth of such robust species as *Silphium terebinthinaceum, S. laciniatum, Baptisia leucantha, Echinacea pallida, Aster laevis,* and *Eryngium yuccifolium.* The xeric prairies,

being found on the warm and exposed open slopes, have a rapid development of optimal growing conditions along with a confinement of favorable moisture to the spring months. Consequently they provide us with our earliest spring flowers, including *Anemone patens, Ranunculus fascicularis,* and *Geum triflorum.* Other plants typical of this community are *Petalostemum purpureum, Baptisia leucophaea, Amorpha canescens, Aster sericeus,* and the spectacular, deep-blue *Gentiana puberulenta.* The ubiquitous *Aster novae-angliae* and the exceptionally rare and beautiful *Habenaria leucophaea* as well as a variety of other species, including *Veronicastrum virginicum, Liatris pycnostachya,* and *Gentiana andrewsii,* inhabited the low prairies. In the sedge meadows *Cardamine bulbosa, Asclepias incarnata,* and *Caltha palustris* were almost always present. Fens, wet springy meadows with a rich internal supply of calcium, boasted such distinctive species as *Cypripedium candidum, Gentiana crinita,* and *Parnassia glauca.*

Prairie fires were once a regular occurrence on the grasslands throughout the Midwest, and their frequency was doubtless increased by the hunting practices of local Indians. While woody species can be severely limited by fire, prairie species are well adapted to fire and often require it for optimal growth. It is not surprising that the fires maintained the savannas in an open condition and limited their encroachment onto the prairie.

While prairie fires could limit tree reproduction, they could never kill the established oaks. This permanence has led to considerable discussion as to why large areas of the county supported no trees whatsoever at the time of settlement. Prairies are found on areas of flat topography with fine-textured soil. This would have allowed desiccating winds to sweep freely across them, causing severe damage during periods of intense winter cold or summer drought and increasing the intensity of fires. Together these factors seem sufficient to explain the inability of the oaks to invade the prairies rapidly but cannot explain why they did not invade at all. Curtis (1959) proposed that the prairies represent areas of climax maple-basswood forest of a cooler and moister period. These forests were supposedly eradicated by fires following a climatic shift while the oak forests remained as savannas. This suggestion seems untenable, however, since one would normally expect the climax forests to have been present on the mesic lowlands or on the north-facing slopes, rather than on the hot and dry uplands, the normal habitat of the oaks. Instead it appears that at the time of settlement the oaks were in the process of spreading across the grasslands, which resulted from a previous period of prairie maximum, and that these savanna trees had not yet become established on the environmentally more severe areas.

The original savanna dominants were primarily oaks, *Quercus macrocarpa, Q. alba,* and *Q. velutina,* which are adapted in some form to withstand the frequent fires. In addition, *Carya ovata* and *Populus tremuloides* were both of frequent occurrence. On the north-facing slopes, with a damper and cooler microclimate as well as greater protection from fire, a different and more diverse set of species occurred. Included were *Quercus borealis, Ulmus rubra, Juglans nigra, Fraxinus pennsylvanica, Prunus serotina, Tilia americana,*

Map 1. The original vegetation of Rock County about 1835.

(Prepared from surveyors' records by Michael Moore).

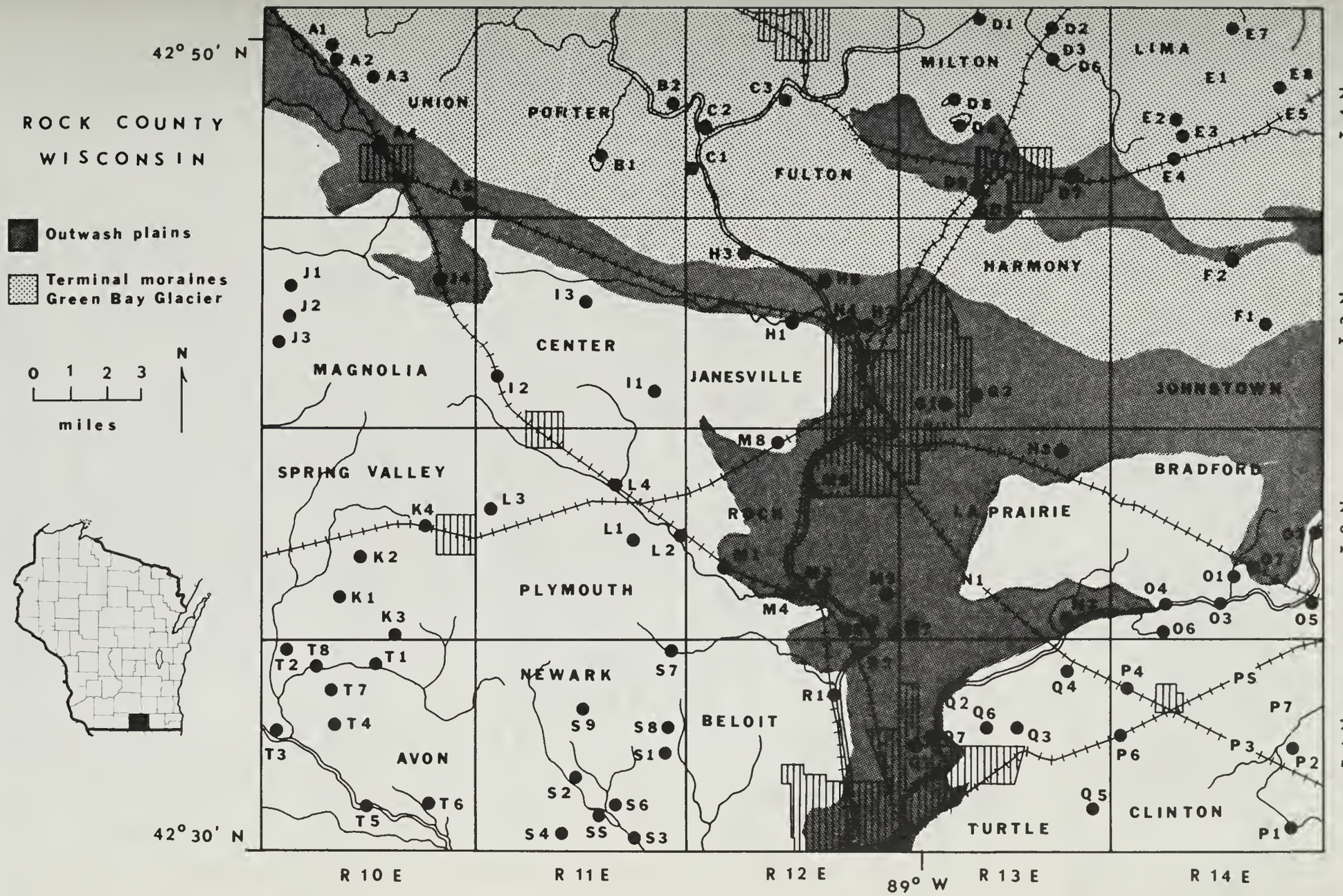
Ostrya virginiana, Celtis occidentalis, and an occasional *Acer saccharum.* The wet savannas and forests of riverbottoms, which constituted less than 0.5% of the total land area of the county, were dominated by *Acer saccharinum, Ulmus americana, Fraxinus pennsylvanica,* and *Salix* along with an occasional *Quercus bicolor.*

The lack of natural savannas causes modern botanists to place far too little importance on them when discussing the habitats and distribution of species. Today we can only guess as to the composition of their herbaceous strata. The surveyors' records supply a few hints, listing greenbriar, grape, brambles, bittersweet, and redroot as having been present in the more heavily shaded areas. Curtis mentioned a set of species which seemed to possess bimodal distributions, with their greatest importance in the xeric forests and a secondary maximum in the wet-mesic prairies. While this may resemble a classic case of compensation, an alternative explanation is that the species are now found on both sides of their preferred habitat, the savanna, which no longer exists. Included on the list were *Allium tricoccum, Anemone quinquefolia, Geranium maculatum, Polemonium reptans, Prenanthes alba, Smilax,* and *Vitis.* Additional species which probably reached their optimal growth in the savannas include *Smilacina stellata, Cypripedium calceolus,* and a few of the spring-blooming woodland species, such as *Podophyllum peltatum* and *Claytonia virginica.*

It was only after the cessation of the prairie fires following the advent of European civilization that the savannas grew up into the familiar oak woods of today. Because of their high light intensities, these woods allow the growth of large quantities of such shrubs as *Cornus racemosa* and *Corylus americana.* Herbs such as *Phryma leptostachya, Osmorhiza claytonii, Botrychium virginianum,* and *Smilacina racemosa* are ubiquitous. While these forests are composed of savanna trees today, they will not remain so, for the savanna species are unable to reproduce in the shade of a forest. The composition will probably undergo development toward *Ulmus rubra* and *U. americana,* if they survive the severe depredations of dutch elm disease, *Tilia americana, Prunus serotina, Ostrya virginiana,* and perhaps *Celtis occidentalis* and *Acer saccharum.*

DESIGN OF THE CATALOGUE

The sequence of the families follows that of Gleason and Cronquist (1963), and genera and species are arranged alphabetically. Common synonyms correlate names with those which appear in the regional manuals (Gleason & Cronquist, 1963; Fernald, 1950) and in certain recent portions of the taxonomic literature. An undesignated trinomial refers to a variety except in entries where a subspecies is specified. In several cases the name used here is based upon the latest available monograph or flora and differs from that given in the above two manuals. The "Preliminary Reports on the Flora of Wisconsin" (1929-present), a series of some 60 submonographic treatments of selected Wisconsin families and genera, have been freely consulted.



Map 2. Collection site locations. (Geological features after Alden, 1918).

Asterisks designate species which are not native in Rock County. Collection sites not accommodated by the symbols employed in the key below are identified by township and section whenever possible. Those species which have not been collected by the authors are followed by citations of herbarium specimens, or, lacking that information, references to published records. When the number of sites listed for a species would result in an inaccurate estimate of that species' frequency, a statement of frequency follows the list of sites. In the absence of such a statement, the term "rare" is appropriate if the list contains 1 or 2 stations, "infrequent" if 3-5, "frequent" if 6-10, and "common" if 11 or more.

KEY TO COLLECTION SITES

Section numbers are in parentheses; "C" denotes the center of a section.

A. Union Township. T4N, R10E.
   1. Leatherleaf bog, cat-tail marsh N of West Union Rd. (9 NW).
   2. River bulrush marsh N of Butts Corners Rd. (9 S).
   3. Kettle-hole marsh S of Butts Corners Rd. (15 NW, 16 NE).
   4. Bur-reed marsh by Lake Leota, N of Evansville (22 SW).
   5. Sedge meadow along CNW RR, E of Weary Rd. (36 SE).

B. Porter Township. T4N, R11E.
   1. Gibbs Lake, cat-tail marsh, oak woods (27 C).
   2. Wooded slopes, prairie remnants near Fulton Cemetery (13 SE).

C. Fulton Township. T4N, R12E.
   1. Gravel-hill prairies W of Hwy. 184, S of Gibbs Lake Rd. (30 NW).
   2. Bottomland woods at confluence of Rock, Yahara Rivers (19 C).
   3. Limestone cliffs along Rock River W of Hwy. 51 (16).

D. Milton Township. T4N, R13E.
   1. Marshes by Lake Koshkonong, E of Charlie Bluff Rd. (4 NW).
   2. Prairies, marshes along CNW RR, N of Hwy. N (2, 10 NE).
   3. Bur-reed marsh E of Hwy. 26, N of Hwy. N (11 NW).
   4. Clear Lake and its N, E shores (20 NE, 21 NW).
   5. Gravel-hill prairie E of Hwy. Y, N of Townline Rd. (33 S).
   6. Otter Creek (3, 10-13).
   7. Storrs Lake, marsh W of lake, E of Milton (26 SE).
   8. Grass Lake, marsh W of Hwy. 59, NE of Lake Rd. (17 NE).
   9. Pond, muddy shore S of Manogue Rd., W of Hwy. Y (33 N).

E. Lima Township. T4N, R14E.
   1. Tamarack bog, shallow lake, fen, sedge meadows (9, 10, 15, 16).
   2. Low prairie, cat-tail-bulrush marsh W of Hwy. KK (20 NE).
   3. Low prairies, sedge meadows N of Willow Dr. (21 C).
   4. Peat meadow, sedge meadows by CMStPP RR, W of Hwy. KK (29 E).
   5. Prairie along CMStPP RR, E of Lima Center (13, 14, 22, 23).
   6. Kettle-hole marsh N of Hwy. 59 (29 S).
   7. Mud flat, low prairie, pond, drainage ditch N of Hwy. N (3 S).
   8. Kettle-hole marsh E of McCord Rd. (14 NE).

F. Johnstown Township. T3N, R14E.
   1. Oak woods on Johnstown moraine E of Scharine Rd. (14 S).
   2. Sedge meadow by Lima Center Rd., N of Six Corners Rd. (10 N).

G. Harmony Township. T3N, R13E.
   1. Gravel-hill prairies N of Hwy. MM (33).
   2. Gravel-hill prairie S of Hwy. MM, W of Wright Rd. (32 NE).

H. Janesville Township. T3N, R12E.
   1. Wooded slopes, gravel-hill prairies, low woods by Marsh Creek in and near Janesville Schools Outdoor Laboratory (15, 16, 21, 22).
   2. Mixed oak woods on limestone along Hwy. F (23 NE, 24 NW).
   3. Boggy area S of Rock River, W of Fitzsimmons Rd. (5 S).
   4. Sugar maple-red oak woods, cliff in Riverside Park (14 S, 23).
   5. Upland hardwoods, cultivated land along Rock River (10 C).

I. Center Township. T3N, R11E.
   1. Gravel-hill prairies along Mineral Point Rd. (25 SW, 26, 35 NE).
   2. Exposed sandstone slopes, dry prairie E of CNW RR (30).
   3. Oak-maple woods N of Whitmore Rd. (15 W). (Specimens in herbarium of K. Rabideau, Jackson Junior High School).

J. Magnolia Township. T3N, R10E.
   1. Sandy black oak woods, dry S-facing sandstone cliff, N-facing slope with white birch in Magnolia Bluff Park (7 SE, 18 NE).
   2. Eroded sandstone slopes, outcrops near Calvary Cemetery (18 NW).
   3. Sandstone slopes, outcrops S of Hwy. A (19 C).
   4. Low prairie, sedge meadow along CNW RR, E of Marsh Rd. (12 SW).

K. Spring Valley Township. T2N, R10E.
   1. Upland hardwoods S of West Church Rd., W of Dickey Rd. (28 SW).
   2. Sandy slopes, N-facing outcrops W of Nelson Rd. (21 NE).
   3. Oak-elm woods E of Gilbert Rd. at North Townline Rd. (34 SE).
   4. Prairie remnants along CMStPP RR, elsewhere in section (14).

L. Plymouth Township. T2N, R11E.
   1. Sandy black oak woods, sandstone W of Schuman Rd. (23 W).
   2. Mesic, wet-mesic prairies, sedge meadow, fen, drainage ditches along CNW RR, W of Kessler Rd. (13 SE, 24 NE).
   3. Marsh by Old Eleven Rd. (18 N), sandy drainage ditch (18 E).
   4. Low prairie along CNW RR, NW of Hanover (10, 11 SW).

M. Rock Township. T2N, R12E.
   1. Sand prairie along CNW RR, E of Murray Rd. (20 SW).
   2. Grazed gravel-hill prairie N of Happy Hollow Rd. (25 SE).
   3. Lowland woods, marshes N of Rock River (27 C).
   4. N-facing sandstone bluff S of Bass Creek, W of Hwy. D (28 SE).
   5. Rock County Campus of University of Wisconsin, adjoining weedy fields, low woods E of Rock River, S of campus (10 S).
   6. Disturbed lowland hardwoods by Rock River W of Hwy. 51 (36 W).
   7. Low pasture E of river (36), gravel pit W of Hwy. G (36 SE).
   8. Various habitats (4), including CMStPP right-of-way (4 NE).

N. La Prairie Township. T2N, R13E.
   1. Mesic prairie along CNW RR (7, 17, 18, 20, 28, 34, 35).
   2. Grazed low woods, marshes, water of Turtle Creek (35, 36).
   3. Fencerows on cultivated land (2).

O. Bradford Township. T2N, R14E.
   1. Woods, stream, limestone cliffs in Carver-Roehl Park (27 N).
   2. Wet meadows, marshes, fen, springs by Turtle Creek (13, 24).
   3. Marshes, springs, dry limestone cliffs, oak woods along Turtle Creek W of Carvers Rock Rd. (27 SW, 28 SE).

4. Dry ditch N of Creek Rd., E of Hwy. 140 (29), red oak-sugar maple woods, marshes S of Turtle Creek along Hwy. 140 (32 N).
5. CMStPP RR (36), edges of small streams (25 SW, 36).
6. Quarry, narrow-leaved cat-tail marsh W of Dunn Rd. (32 SE).
7. Marshes along CMStPP RR, edges of small streams (22, 26).

P. Clinton Township. T1N, R14E.

1. Mixed oak woods, edges of streams (35 NE, 36).
2. Mixed oak woods (23, near railroad; 24 E).
3. CNW RR, E of Clinton (15, 16, 23-25).
4. CNW RR, W of Clinton (7 NW).
5. CMStPP RR, E of Clinton (1-3, 9, 10).
6. CMStPP RR, W of Clinton (18 SW).
7. Sides of Terwilliger Rd., streamsides, woods (12-14).

Q. Turtle Township. T1N, R13E.

1. Murphy Woods (mixed oak-hackberry) W of Shopiere Rd. (18 S).
2. Turtle Creek floodplain (9, 17, 18, 20).
3. Mixed oak woods S of Hart Rd., W of Butterfly Rd. (15 C).
4. Mixed oak woods SW of CNW RR (2 E).
5. Mixed oak-elm woods S of Hwy. P (25 S).
6. Sides of Hart Rd., E of Lathers Rd. (16 C).
7. Gravel pit on Turtle Creek west terrace at Creek Rd. (18 E).

R. Beloit Township. T1N, R12E.

1. Red oak-sugar maple woods, adjacent woods, marshes, CNW RR in Big Hill Park (11 SW).
2. Gravel-hill prairies along Rock River, marsh E of River (1, 2).

S. Newark Township. T1N, R11E.

1. Wet-mesic prairie, woods, ditches N of Newark Rd. (13 S).
2. Wet prairie, sedge meadow W of Olson Rd., N of Hwy. 81 (21 SE).
3. Wet prairie, sedge meadow N of St. Lawrence Rd. (35 C).
4. Dry sandy black oak woods E of Hwy. K (33 S).
5. Lowland woods, marshes along west edge of Mill Pond (27 S).
6. Wet-mesic prairie, fen, ditch E of Hwy. H (26 SW).
7. Wet field, streamsides W of Johnson Rd. (1 E).
8. Mixed oak woods S of Cleophas Rd. (13 N).
9. Oak–hickory woods E of Pinnow Grove Rd. (10 SW).

T. Avon Township. T1N, R10E.

1. Black oak woods on S-facing sandstone slope, marsh N of Willow Creek, E of Nelson Rd. (3 SW).
2. Dry prairie on limestone, wooded sandy slopes N of North Townline Rd. (6 NE).
3. Lowland forests, sloughs, sedge meadows, low prairies, including Swenson Prairie Scientific Area, N of Sugar River (18).
4. Dry-mesic prairie on limestone ridge E of Avon Cemetery (17 E).
5. Low forest, including Avon Bottoms Scientific Area, Nelson Road Park, sloughs, sandbars, marshes, sedge meadows (27, 28).
6. Sandy black oak woods, sedge meadows (26 SE), sides of Brandherm Rd. (25).
7. Oak woods on sandy slope at Skinner Rd., Hwy. 81 (8 E, 9 W).
8. Sedge meadows, shrub-carr along Willow Creek at Avon Store Rd. (5 SE).

CATALOGUE OF SPECIES

LYCOPODIACEAE (Clubmoss Family)

Lycopodium complanatum L. *Groundpine.* Dry oak woods, H1.
L. lucidulum Michx. *Shining clubmoss.* Wooded N-facing slope, J1, locally abundant.

SELAGINELLACEAE (Spikemoss Family)

Selaginella rupestris (L.) Spring. *Spikemoss.* Dry sandstone, I2 J1 J2 J3 L1 T1, locally abundant.

EQUISETACEAE (Horsetail Family)

Equisetum arvense L. *Common horsetail.* Railroads, roadsides, fields, J4 L2 L3 O5 O6 P2 P3 P4 P5 P6 P7 T3.
E. Xferrissii Clute (E. laevigatum X E. hyemale affine) (E. laevigatum of Tryon et al., 1953) *Ferriss' horsetail.* Along Little Turtle Creek, O5.
E. fluviatile L. *Water horsetail.* Shallow water, E1 O2 P3 S3 T4.
E. hyemale L. var. affine (Engelm.) A. A. Eat. *Scouring rush.* Railroads, N1 O5 P2 P3 P4; low prairie, O2.
E. laevigatum A. Br. (E. kansanum of Tryon et al., 1953) *Smooth horsetail.* Mesic prairies, J4 L2 P3 P4 P5 P6.
E. palustre L. *Marsh horsetail.* Spring, H3.

OPHIOGLOSSACEAE (Adder's Tongue Family)

Botrychium dissectum Spreng. *Cut-leaved grapefern.* Var. dissectum: woods, L1 (! Musselman, Peet). Var. obliquum (Muhl.) Clute: woods, T7, S9 (! Peet).
B. multifidum (Gmel.) Rupr. *Leather grapefern.* Wooded sandstone, J1.
B. virginianum (L.) Sw. *Rattlesnake fern.* Upland woods, F1 H1 J1 K2 L1 O4 Q1 R1 S4 S8.

OSMUNDACEAE (Royal Fern Family)

Osmunda cinnamomea L. *Cinnamon fern.* Wooded slopes, J1 R1.
O. claytoniana L. *Interrupted fern.* Wooded slopes, A1 R1.
O. regalis L. var. spectabilis (Willd.) Gray. *Royal fern.* Intermittent pond in sandy oak woods, T7, one plant.

POLYPODIACEAE (Polypody Family)

Adiantum pedatum L. *Maidenhair fern.* Mesic woods, F1 H1 J1 O4 Q1 Q5 R1 S8.
Asplenium platyneuron (L.) Oakes. *Ebony spleenwort.* Sandy wooded slopes, J1 L1.
Athyrium filix-femina (L.) Roth. *Lady fern.* Woods, J1 K2 R1 T7.
Camptosorus rhizophyllus (L.) Link. *Walking fern.* Shaded limestone, C3 O3.
Cryptogramma stelleri (S. G. Gmel.) Prantl. *Rockbrake.* Limestone cliff, H2.
Cystopteris bulbifera (L.) Bernh. *Bulblet fern.* Shaded limestone, H2 O1.
C. fragilis (L.) Bernh. *Fragile fern.* Rocky woods, J1 O4 T7.
Dryopteris cristata (L.) Gray. *Crested woodfern.* Sphagnum bog, E1.
D. spinulosa (O. F. Müll.) Watt, *sensu lato* (D. austriaca) *Spinulose woodfern.* Sandy wooded slopes, J1 L1 S8.
Onoclea sensibilis L. *Sensitive fern.* Low woods, wet prairies, thickets, A1 D1 D3 E1 O2 R1 S2 S7 T1 T5.
Pellaea glabella Mett. *Cliffbrake.* Limestone cliffs, C3 H2 J1 O1 O3 T1 T2.
Polypodium virginianum L. (P. vulgare) *Polypody.* Shaded rocks, J1 J3 L1 M4 T1 T7.
Pteridium aquilinum (L.) Kuhn. var. latiusculum (Desv.) Underw. *Bracken.* Dry woods, L1 S8 T6 T7; railroads, P2 P3.
Thelypteris palustris Schott (Dryopteris thelypteris) *Marsh fern.* Marshes, low prairies, sedge meadows, A1 E1 O2 S1 S2 T8.
Woodsia ilvensis (L.) R. Br. *Rusty woodsia.* Sandstone, J1 L1.
W. obtusa (Spreng.) Torr. *Blunt-lobed woodsia.* Sandstone, R1 T1.

TAXACEAE (Yew Family)

Taxus canadensis Marsh. *American yew.* Shaded cliffs, H4 O4.

PINACEAE (Pine Family)

*Larix decidua Mill. *European larch.* Spreading from cult., O2.
L. laricina (DuRoi) K. Koch. *Tamarack.* Sphagnum bog, E1, locally abundant.

CUPRESSACEAE (Cypress Family)

Juniperus communis L. var. depressa Pursh. *Common* or *ground juniper.* Dry rocky slopes, J1 (now extinct) R1.
J. virginiana L. *Red Cedar.* Various open habitats, very common.

TYPHACEAE (Cat-tail Family)

Typha angustifolia L. *Narrow-leaved cat-tail.* Marshes, O2 O6.
T. latifolia L. *Common cat-tail.* Shallow water, very common.

SPARGANIACEAE (Bur-reed Family)

Sparganium androcladum (Engelm.) Morong. *Bur-reed.* Marsh, E6 (! Smith).
S. eurycarpum Engelm. *Common bur-reed.* Marshes, ditches, A4 D3 L2 M3 O2 O4 O5 R1 S5 T3.

NAJADACEAE (Pondweed Family)

*Potamogeton crispus L. *Curly-leaved pondweed.* Streams, D6 R1, Center 13 E, locally abundant.
P. foliosus Raf. *Leafy pondweed.* Streams, D6, Turtle 3 E, locally abundant.
P. natans L. *Floating* or *common pondweed.* Ross & Calhoun, 1951.
P. nodosus Poir. *Long-leaved pondweed.* River, R1 (*Fell,* 1957, WIS).
P. pectinatus L. *Fennel-leaved* or *comb pondweed.* Shallow water, B1 D6 D7 D9, locally abundant.
P. pusillus L. *Small pondweed.* Streams, D6 O1, locally abundant.
P. zosteriformis Fern. *Flat-stemmed pondweed.* Rock River at Fulton (*Stout,* 1904, WIS).
Zannichellia palustris L. *Horned pondweed.* Spring, O2, locally abundant.

JUNCAGINACEAE (Arrowgrass Family)

Triglochin elatum Nutt. (T. maritimum agg.) *Arrowgrass.* Sedge meadow, E1, local.

ALISMATACEAE (Water Plantain Family)

Alisma plantago-aquatica L. *Water plantain.* Marsh, E1; sloughs, T3 T5.
A. subcordatum Raf. *Common water plantain.* Marshes, sloughs, ditches, A3 B1 E7 L2 P3 T3.
Sagittaria cuneata Sheld. *Arum-leaved arrowhead.* Ditches, C2 E2 L2, frequent.
S. engelmanniana J. G. Sm. ssp. brevirostra (Mack. & Bush) Bogin. *Short-beaked duck potato* or *arrowhead.* Slough, T3.
S. latifolia Willd. *Common arrowhead.* Sloughs, O2 R2 T3; marshes; common.
S. rigida Pursh. *Stiff arrowhead.* Beloit (*Olds,* 1896, WIS).

HYDROCHARITACEAE (Frog's Bit Family)

Elodea canadensis Michx. (Anacharis c.) *Waterweed.* Quiet water, D4 T3, locally abundant.
E. nuttallii (Planch.) St. John (Anacharis n.) *Waterweed.* Drainage ditch, L2.

GRAMINEAE (Grass Family)

*Agropyron repens (L.) Beauv. *Quackgrass.* Ubiquitous weed.
*A. smithii Rydb. *Western wheatgrass.* Railroad cinders, sand, Turtle 22 NE (*Wadmond, Shinners, & Stearns,* 1941, WIS).
A. trachycaulum (Link) Malte. *Slender wheatgrass.* Ditch, S1.
*Agrostis alba L. (A. gigantea, A. stolonifera) *Redtop.* Damp ground, very common.

A. hyemalis (Walt.) BSP. *Early ticklegrass.* Meadow, Newark 27 (*Shinners & Catenhusen,* 1942, WIS).
A. scabra Willd. *Fly-away grass.* Wooded N-facing sandstone slope, J1.
Alopecurus aequalis Sobol. *Short-awned foxtail.* Low fields, mud, shallow water, A1 A3 E7.
A. carolinianus Walt. *Annual foxtail.* Edgerton (*Johnson,* 1912, WIS).
Andropogon gerardii Vitm. *Big bluestem.* Prairies, very common.
A. scoparius Michx. *Little bluestem.* Dry prairies, very common.
Aristida basiramea Engelm. *Triple-awned grass.* Sandy woods, S4.
*Avena sativa L. *Oats.* Railroad, P3.
Bouteloua curtipendula (Michx.) Torr. *Side-oats grama.* Dry calcareous prairies, C1 D5 E1 E5 G1 G2 H1 I2 J1 M1 M2 R2 T2 T4.
Brachyelytrum erectum (Schreb.) Beauv. *Woodgrass.* Woods, R1.
Bromus ciliatus L. *Fringed brome.* Marshes, O2 S1 S2.
*B. commutatus Schrad. *Smooth chess, brome grass.* Janesville (*Skavlem,* 1915, MIL). Determination questionable.
*B. inermis Leyss. *Smooth brome.* Railroads, roadsides, very common throughout.
*B. japonicus Thunb. *Japanese brome.* Railroad, P5; open disturbed ground, Turtle 30.
B. kalmii Gray. *Prairie brome.* Low prairies, sedge meadows, marshes, E1 E2 J4 L2 R1 S1.
B. latiglumis (Shear) Hitchc. *Ear-leaved brome.* Mesic woods, H4.
B. purgans L. *Woodland brome.* Mesic woods, R1.
*B. tectorum L. *Downy brome* or *chess.* Railroad ballast, roadsides, very common.
Calamagrostis canadensis (Michx.) Beauv. *Bluejoint.* Wet prairies, marshes, E1 E5 J4 T8, common.
Cenchrus longispinus (Hack.) Fern. *Sandbur.* Sandbar, T3; sandy field, T7.
Cinna arundinacea L. *Woodreed.* Wet field, Avon 29 (*Laube, s. d.,* WIS).
*Dactylis glomerata L. *Orchard grass.* Fields, roadsides, very common.
Danthonia spicata (L.) Beauv. *Poverty grass.* Dry open woods, H2 L1.
Diarrhena americana Beauv. var. obovata Gleas. *Beak grass.* Low woods, T5, one colony (*Iltis s.n.,* 1958, WIS). Second Wisconsin collection.
*Digitaria sanguinalis (L.) Scop. *Crabgrass.* Very common weed.
*Echinochloa crusgalli (L.) Beauv. var. crusgalli. *Barnyard grass.* Damp ground, very common.
E. muricata (Beauv.) Fern. *Barnyard grass.* Var. muricata: D7; low pasture, Beloit 1; common. Var. microstachya Wieg.: fencerow, N3 (*Wickham,* 1947, WIS); very common.
Elymus canadensis L. *Wild rye.* Railroads, E5 J4 M1 N1 P3 P4 P5.
E. villosus Muhl. *Silky wild rye.* Mesic woods, R1.
E. virginicus L. *Virginia wild rye.* Low woods, T3 T5; low prairies, S1, Spring Valley 21.
Eragrostis frankii C. A. Mey. *Sandbar lovegrass.* Dry gravel, Fulton 14 (*Aronson & Pierce,* 1967, WIS).
E. hypnoides (Lam.) BSP. *Creeping lovegrass.* Mudflats, O2 O4 O6 T3.
*E. megastachya (Koel.) Link (E. cilianensis) *Stink grass.* Gravel pit, Q7; field, Avon 34; roadsides; frequent.
E. pectinacea (Michx.) Nees. *Small lovegrass.* Roadside, Plymouth 15; frequent.
*E. poaeoides Beauv. *Low lovegrass.* CMStPP RR yard, Janesville (*Shinners,* 1940, WIS).
E. spectabilis (Pursh) Steud. *Purple lovegrass.* Dry prairie, R2; dry open ground; frequent.
Festuca obtusa Spreng. *Nodding fescue.* Mesic woods, R1.
F. octoflora Walt. *Fescue.* S-facing sandy slope, J1.
*F. pratensis Huds. (F. elatior) *Meadow fescue.* Damp roadside, O4.
Glyceria borealis (Nash) Batchelder. *Floatgrass.* Shallow water, A1 D8.

G. grandis S. Wats. *Reed manna.* Beloit (*Lathrop, s. d.,* WIS).
G. septentrionalis Hitchc. *Manna grass.* Marshes, E3 E6.
G. striata (Lam.) Hitchc. *Fowl manna.* Sphagnum bog, E1; fen, D6; woods, P1 T3 T8.
Hierochloe odorata (L.) Beauv. *Sweetgrass.* Low prairies, B1 E2 L2 T3.
*Hordeum jubatum L. *Squirrel-tail barley.* Railroads, roadsides, L2 P6, common.
Hystrix patula Moench (Elymus p.) *Bottlebrush grass.* Woods, H2 O1 R1.
Koeleria macrantha (Ledeb.) Spreng. (K. cristata) *Junegrass.* Sandy to mesic prairies, B2 L2 M2 N1.
Leersia oryzoides (L.) Sw. *Rice cutgrass.* Wet ground, very common.
L. virginica Willd. *Whitegrass.* Low woods, H1 T3 T5.
Leptoloma cognatum (Schult.) Chase. *Fall witchgrass.* Roadsides, sandy fields, R2 S4 T7; moist peat, H3; common.
*Lolium perenne L. *Darnel.* Roadside ditches, S1, Rock 34 W; dam, D6.
Melica nitens Nutt. *Melic grass.* Railroad, Beloit 25 S (*Wadmond, s. n.,* 1937, WIS). In Wisconsin known only from Rock and Iowa counties.
Muhlenbergia frondosa (Poir.) Fern. *Muhly.* Ditch, H2; streambank, O5; low woods, T3.
M. mexicana (L.) Trin. *Muhly.* Low prairies, marshes, D7 O2 S1 S3; frequent.
M. racemosa (Michx.) BSP. *Muhly.* Woods, H1; prairie, P3.
M. schreberi Gmel. *Nimblewill.* Low ground, Bradford 27 (*Fell,* 1957, WIS).
M. sylvatica Torr. *Muhly.* Low woods, T3.
Oryzopsis racemosa (Sm.) Ricker. *Ricegrass.* Woods, H2 O1 T7.
Panicum capillare L. *Witchgrass.* Fields, roadsides, mudflats, O4 P5 Q2 S7 T7; common.
P. columbianum Scribn. *Panic grass.* Sandy prairie, I2.
P. depauperatum Muhl. *Starved panic grass.* Dry sandy or gravelly slopes, I1 L1 M2.
P. dichotomiflorum Michx. *Fall panic grass.* Roadsides, railroads, especially cult. fields, J2 O4; frequent.
P. flexile (Gatt.) Scribn. *Wiry panic grass.* Sedge meadow, E1.
P. lanuginosum Ell. (P. implicatum) *Hairy panic grass.* Dry slopes, B2 J1 J2 L1 M4 O1; damp peat, H3.
P. latifolium L. *Broad-leaved panic grass.* Mesic woods, L1 O1 R1.
P. leibergii (Vasey) Scribn. *Prairie panic grass.* Dry to mesic prairies, K4 L2 L4 N1 P5 P6.
P. linearifolium Scribn. *Slender-leaved panic grass.* Dry prairie, T2.
P. oligosanthes Schult. var. scribnerianum (Nash) Fern. *Scribner's panic grass.* Dry to mesic prairies, B2 D5 H1 I2 J1 L2 M2 N1 T3.
P. perlongum Nash. *Long-stalked panic grass.* Dry prairie, B2.
P. praecocius Hitchc. & Chase. *Early panic grass.* Sandy slope, J2.
P. virgatum L. *Switchgrass.* Railroad, P3.
Phalaris arundinacea L. *Reed canary grass.* Wet ground, very common.
*Phleum pratense L. *Timothy.* Grassy roadsides, fields, common.
Phragmites australis (Cav.) Steud. (P. communis) *Reed grass.* Marshes, C2 E1 E3 F2 H3 L3 T8.
*Poa compressa L. *Canada bluegrass.* Ubiquitous weed of dry ground.
P. palustris L. *Fowl bluegrass.* Sedge meadows, shores, mud, A3 D8 E1 S7.
*P. pratensis L. *Kentucky bluegrass.* Ubiquitous weed.
*P. trivialis L. *Rough bluegrass.* Low woods, Union 22.
*Secale cereale L. *Rye.* Roadside, Bradford 19 E.
*Setaria faberi Herrm. *Giant foxtail.* Roadsides, L3 O7; pasture, Porter 2.
*S. glauca (L.) Beauv. (S. lutescens) *Yellow foxtail, pigeon grass.* Very common weed.
*S. verticillata (L.) Beauv. *Bristly foxtail.* Disturbed ground, L3.
*S. viridis (L.) Beauv. *Green foxtail.* Ubiquitous weed, especially of cult. ground.
Sorghastrum nutans (L.) Nash. *Indian grass.* Mesic prairies, very common.
Spartina pectinata Link. *Cordgrass, slough grass.* Wet prairies, A1 B1 D3 E1 E2 E3 E4 E5 J4 L2 O2 O3 O5 P3 P5 P6 S1 T3.

Sphenopholis intermedia (Rydb.) Rydb. *Wedgegrass.* Sandstone railroad cut, Turtle 22 (*Wadmond, Shinners, & Stearns,* 1941, WIS).
Sporobolis asper (Michx.) Kunth. *Rough dropseed.* Prairie, H1.
S. cryptandrus (Torr.) Gray ssp. fuscicolus (Hook.) Jones & Fassett. *Sand dropseed.* Railroad ballast, Turtle 22 (*Wadmond, Shinners, & Stearns,* 1941, WIS).
S. heterolepis Gray. *Prairie dropseed.* Dry to mesic prairies, D5 M2 N1 R2 S1.
S. neglectus Nash. *Small rushgrass.* Dry gravel, Fulton 14 (*Pierce & Aronson,* 1967, WIS).
S. vaginiflorus (Torr.) Wood var. inaequalis Fern. *Poverty grass.* Ellis woods, Union NW (*Iltis & Ugent,* 1961, WIS).
*Stipa comata Trin. & Rupr. *Needlegrass.* Railroad ballast, A5 P3.
S. spartea Trin. *Porcupine grass.* Dry prairies, G2 I2 M1 N1 P3 P5 T3.
*Triticum aestivum L. *Wheat.* Railroads, P3 P4; roadsides.
*Zea mays L. *Maize, Indian corn.* Occasional escape from cult.
Zizania palustris L. var. interior (Fassett) Dore (Z. aquatica) *Wild rice.* Shallow water, E1 O2 O3 O5.

CYPERACEAE (Sedge Family)

Bulbostylis capillaris (L.) Clarke. *Hair sedge.* Dry sand, T7.
Carex abdita Bickn. (C. umbellata *sensu* Gleas. & Cronq.) *Hidden sedge.* Prairies, D5 G1 G2 I1 J1 L2 M2 R2 T2 T4.
C. albursina Sheld. (C. laxiflora latifolia) *Sedge.* Woods, H4 R1.
C. alopecoidea Tuckerm. *Foxtail sedge.* Riverbottom, T3 (*Fell,* 1957, WIS).
C. amphibola Steud. var. turgida Fern. *Gray sedge.* Low woods, M6 T3; infrequent.
C. aquatilis Wahl. var. altior (Rydb.) Fern. *Water sedge.* Sphagnum bog, E1.
C. atherodes Spreng. *Sedge.* Shallow water, D8.
C. bebbii Olney. *Bebb's sedge.* Edges of wet areas, E4 O6 S3 T3 T8.
C. bicknellii Britt. *Bicknell's sedge.* Prairies, H1 J4 M2 S1 T3.
C. blanda Dew. (C. laxiflora b.) *Wood sedge.* Woods, F1 H2 O1 O3 O4 P7 Q1 R1 T3; common.
C. brevior (Dew.) Mackenz. *Sedge.* Railroad, R1; frequent.
C. buxbaumii Wahl. *Buxbaum's sedge.* Fens, low prairies, E1 J4 L2 P5 S1 T3.
C. cephalophora Muhl. *Woodbank sedge.* Prairies, H1 T3; infrequent.
C. chordorrhiza L. f. *Creeping sedge.* Sphagnum bog, E1, locally abundant.
C. comosa Boott. *Bristly sedge.* Sloughs, marshes, D8 E1 E3.
C. conoidea Schk. *Field sedge.* Wet-mesic prairie, S1.
C. convoluta Mackenz. (C. rosea *sensu* Gleas. & Cronq.) *Star sedge.* Woods, F1 J1 R1.
C. cristatella Britt. *Crested sedge.* Low woods, M3; ditch, F2; infrequent.
C. davisii Schw. & Torr. *Davis' sedge.* (Zimmerman, MS ined.).
C. diandra Schrank. *Panicled sedge.* Sphagnum bog, E1.
C. disperma Dew. *Two-seeded sedge.* Sphagnum bog, E1.
C. emoryi Dew. (C. stricta elongata) *Emory's sedge.* Sedge meadows, L2 O3 T3 T5.
C. foenea Willd. (C. siccata) *Hay sedge.* Low prairies, T3, Rock 29; frequent.
C. granularis Muhl. *Meadow sedge.* Open grassy woods, O1.
C. gravida Bailey. *Sedge.* Railroad ballast, N1; infrequent.
C. grayii Carey. *Bur sedge.* Low woods, T3 T5.
C. haydenii Dew. *Hayden's sedge.* Wet prairies, sedge meadows, B1 E1 J4 L2 T3 T5.
C. hirtifolia Mackenz. *Hairy sedge.* Woods, E4 O4 T5.
C. hystericina Muhl. *Bottlebrush sedge.* Marshes, shores, D3 E1 O2 T6.
C. interior Bailey. *Inland sedge.* Wet places, D3 E1 H3 T8.
C. lacustris Willd. *Lake sedge.* Marshes, E2 E4 O2.
C. lanuginosa Michx. (C. lasiocarpa latifolia) *Woolly sedge.* Sedge meadows, D3 L2 S1 T1 T3 T6.
C. lasiocarpa Ehrh. var. americana Fern. *Sedge.* Shallow water in bogs, A1 E1.
C. leptalea Wahl. *Delicate sedge.* Sphagnum bog, E1.
C. livida (Wahl.) Willd. var. grayana (Dew.) Fern. *Sedge.* Sphagnum bog, E1 (*Iltis,* 1969, WIS).

C. lupulina Muhl. *Hop sedge.* Low woods, T3 T5.
C. meadii Dew. *Mead's sedge.* Mesic prairies, D5 G1 G2 M1 M2; frequent.
C. molesta Mackenz. *Sedge.* Low woods, T5 (*Fell,* 1957, WIS).
C. muhlenbergii Schk. *Sand sedge.* Sandy slopes, I2 J1 J2 T1 T7; common.
C. normalis Mackenz. *Sedge.* Woods, Q1 T5; prairie, M8.
C. oligocarpa Schk. *Sedge.* Woods, R1.
C. paupercula Michx. *Sedge.* Sphagnum bogs, A1 E1.
C. pedunculata Muhl. *Stalked sedge.* Mesic woods, H2.
C. pensylvanica Lam. *Pennsylvania* or *early sedge.* Ubiquitous in open woods and on dry prairies.
C. projecta Mackenz. *Beaded broomsedge.* Low woods, T3 T5.
C. retrorsa Schw. *Hooked sedge.* Low woods, T3; infrequent.
C. richardsonii R. Br. *Richardson's sedge.* Prairies, C1 D5 G1 G2 I1 L2 M2 R2 T2 T4.
C. rosea Schk. *Sedge.* Woods, Q1.
C. rostrata Stokes var. utriculata (Boott) Bailey. *Beaked sedge.* Springy marsh, Lima 8 (*Iltis,* 1969, WIS).
C. sartwellii Dew. *Sartwell's sedge.* Sedge meadows, B1 E1 E2 L2.
C. scoparia Schk. *Broom sedge.* Prairie, O2; mud, D8; marsh, A3; common.
C. sparganioides Muhl. *Bur sedge.* Woods, Q1 Q5; infrequent.
C. sprengelii Dew. *Long-beaked sedge.* Open woods, Q1; limestone, O3 R1; roadside, La Prairie 35 SE.
C. sterilis Willd. *Sedge.* Sphagnum bog, E1.
C. stipata Muhl. *Awl sedge.* Low woods, wet meadows, ditches, P5 T1 T3 T5 T6 T8; common.
C. stricta Lam. *Hassock sedge.* Marshes, B1 H3 J4 L2; common.
C. suberecta (Olney) Britt. *Sedge.* Ditch, T6 (*Fell,* 1957, WIS).
C. tenera Dew. *Sedge.* Low woods, T5.
C. tenera X C. projecta. *Sedge.* Low woods, T6.
C. tetanica Schk. *Sedge.* Low prairies, E2 L2 S1 T8.
C. tribuloides Wahl. *Blunt broomsedge.* Ditch, T5 (*Fell,* 1957, WIS).
C. trichocarpa Muhl. *Hairy sedge.* Ditch, T8; marsh, Union 22; shrub-carr, 02.
C. vesicaria L. *Inflated sedge.* Shallow water, B1.
C. vulpinoidea Michx. *Fox sedge.* Damp ground, very common.
Cladium mariscoides (Muhl.) Torr. *Twig rush.* Sedge meadow, E1.
Cyperus diandrus Torr. *Strand cyperus.* Beloit (*Swezey,* 1876, WIS).
C. esculentus L. *Yellow nutgrass.* Mudflats, O4 O6 T3.
C. filiculmis Vahl. var. filiculmis. *Galingale.* Dry sandy slopes, K2 M1 T7.
C. rivularis Kunth. *Brook sedge.* Drainage ditches, H1 L2 S5.
C. schweinitzii Torr. *Schweinitz' umbrella sedge.* Sandy slope, I2; railroad ballast, D2.
C. strigosus L. *Straw cyperus.* Mud, wet sand, ditches, O2 O4 O6 S1 S6 S7 T3.
Dulichium arundinaceum (L.) Britt. *Three-way sedge.* Sphagnum bogs, A1 E1.
Eleocharis acicularis (L.) R. & S. *Needle spikerush.* Ponds, marshes, sloughs, D3 T3; spring, O2; mudflat, O4.
E. erythropoda Steud. (E. calva) *Spikerush.* Wet ground, H3 T3; infrequent.
E. obtusa (Willd.) Schult. *Blunt spikerush.* Marshes, A3 T3.
E. smallii Britt. (E. palustris) *Small's spikerush.* Shallow water, B1 D3 E1 L2 O2 O4 P1 P5 P7 T3 T5.
Eriophorum angustifolium Honck. *Narrow-leaved cottongrass.* Sphagnum bogs, A1 E1; fen, D6.
E. gracile Koch. *Slender cottongrass.* Sphagnum bog, E1.
E. viridi-carinatum (Engelm.) Fern. *Tall cottongrass.* Sphagnum bog, E1.
Rhynchospora alba (L.) Vahl. *Beak rush.* Sphagnum bog, E1, few plants.
Scirpus acutus Muhl. *Hard-stem bulrush.* Shallow water, sphagnum bog, E1.
S. americanus Pers. *Three-square.* Shallow water, E1 E2 T8.
S. atrovirens Willd. *Dark-green bulrush.* Wet places, M3 O2 O3 O5 O6 O7 P1 P3 S7 T3 T8.

S. cyperinus (L.) Kunth. *Woolgrass.* Wet places, M3 T3; infrequent.
S. fluviatilis (Torr.) Gray. *River bulrush.* Marshes, A2 A3 D8.
S. heterochaetus Chase. *Slender bulrush.* Marsh, E6.
S. pedicellatus Fern. *Woolgrass.* Kettle-hole marsh, Milton 10.
S. validus Vahl. *Soft-stem bulrush.* Shallow water, B1 D2 E1 E2 E4 O2 O5 Q2 S7 T3 T8.

ARACEAE (Arum Family)

Acorus americanus (Raf.) Raf. (A. calamus) *Sweetflag.* Marshes, M3 O4 R1 T3 T5.
Arisaema dracontium (L.) Schott. *Green dragon.* Rich woods, especially river bottoms, Q1 T3 T5.
A. triphyllum (L.) Schott (A. atrorubens) *Jack-in-the-pulpit.* Rich woods, H2 H3 K2 K3 O1 O4 P7 Q1 R1 S5 S8 T5.
Symplocarpus foetidus (L.) Nutt. *Skunk cabbage.* Wet woods, springs, D3 H1 H3 O1 O2 O3 O4.

LEMNACEAE (Duckweed Family)

Lemna minor L. *Small duckweed.* Floating on water, damp soil, very common.
L. trisulca L. *Star duckweed.* Springs, ponds, marshes, ditches, floating just below water surface, E2 E8 K2; frequent.
Spirodela polyrhiza (L.) Schleid. *Duckweed, water flaxseed.* Bog lake, E1; marsh, O4.
Wolffia columbiana Karst. *Common wolffia, water meal.* Marshes, floating just below water surface, D6 O2 O7.

COMMELINACEAE (Spiderwort Family)

Tradescantia ohiensis Raf. (T. reflexa, T. canaliculata) *Spiderwort.* Prairies, roadbanks, railroads, very common.

PONTEDERIACEAE (Pickerelweed Family)

Zosterella dubia (Jacq.) Small (Heteranthera d.) *Water stargrass.* Lake Koshkonong, Edgerton (*Davis,* 1922, WIS).

JUNCACEAE (Rush Family)

Juncus balticus Willd. var. littoralis Engelm. *Lake shore rush.* Marsh, D3.
J. dudleyi Wieg. *Dudley's rush.* Damp openings, H3 S1 T8; shore, A4.
J. greenei Oakes & Tuckerm. *Greene's rush.* Sand hills 7 miles W of Beloit (*Anthoney,* 1933, WIS).
J. nodosus L. *Joint rush.* Wet prairies, L2 O2 S6; marsh margin, A3.
J. tenuis Willd. (J. macer) *Path rush.* Openings in woods, H1 J1 L1 O1 O2 T3 T5; common.
J. torreyi Cov. *Torrey's rush.* Ditches, slough and marsh margins, E4 L2 O2 S6 S7 T3.
Luzula campestris (L.) DC. var. multiflora (Retz.) Celak. *Woodrush.* Woods, fields, D2 L1 O2 T1.

LILIACEAE (Lily Family)

Aletris farinosa L. *Unicorn root.* Beloit (*Lapham,* 1867, WIS).
Allium canadense L. *Wild garlic.* Woods, H1 H2 O4 R1 T5; prairies, E5 K4.
A. tricoccum Ait. *Wild leek.* Woods, H1 O1 O3 Q1 R1 S8.
*Asparagus officinalis L. *Asparagus.* Fields, roadsides, open woods, H2 O4 P3 P5 Q1 T7; common.
Camassia scilloides (Raf.) Cory. *Wild hyacinth.* Beloit (*Fisk,* 1877, WIS). Undoubtedly extinct.
*Convallaria majalis L. *Lily-of-the-valley.* Janesville (*Skavlem,* 1890, WIS).
Erythronium albidum Nutt. *White dog's-tooth violet.* Woods, O3 O4 Q1 R1, locally abundant.
*Hemerocallis fulva L. *Orange day lily.* Persisting near dwellings and along roads, P6; frequent.
Lilium philadelphicum L. var. andinum (Nutt.) Ker. *Wood lily.* Prairies, G2 N1 P5 P6.

L. michiganense Farw. (L. superbum) *Turk's-cap lily.* Wet to mesic prairies, E5 J4 L2 P3 P5 S1.

Maianthemum canadense Desf. *Wild lily-of-the-valley.* Var. canadense: sphagnum bog, E1. Var. interius Fern.: woods, J1 J3 O4 T6.

Polygonatum biflorum (Walt.) Ell. (Incl. P. canaliculatum, P. commutatum) *Great Solomon's seal.* Open woods, roadsides, B2 H1 J1 K2 L1 O4 P3 P4 P7 Q1 S8.

P. pubescens (Willd.) Pursh. *Small Solomon's seal.* Woods, R1.

Smilacina racemosa (L.) Desf. *False spikenard.* Open mesic woods, occasionally prairies, H2 I3 J1 K2 L1 O1 P1 Q1 S4 S8 S9 T7.

S. stellata (L.) Desf. *False Solomon's seal.* Open woods, prairies, E5 G1 H1 I3 K2 L2 N1 P3 P7 Q1 S9 T5 T7.

Smilax ecirrata (Engelm.) S. Wats. *Upright carrion flower.* Woods, O4 Q1 R1 T5.

S. hispida Muhl. (S. tamnoides h.) *Greenbriar.* Woods, H2 Q1 T3 T5 T7 T8.

S. illinoensis Mangaly (S. ecirrata X S. lasioneura?) *Carrion flower.* Mesic to low woods, T3 T5.

S. lasioneura Hook. *Common carrion flower.* Open woods, fencerows, B2 H1 H2 H4 K2 Q6 S8 T7.

Trillium flexipes Raf. (T. gleasonii) *Declined trillium.* Woods, O3 O4 Q1.

T. grandiflorum (Michx.) Salisb. *Large-flowered trillium.* Mesic woods, I3 O4 Q1 R1.

T. recurvatum Beck. *Purple wake-robin, red trillium.* Woods, O3 O4 Q1 R1 T3 T5, locally abundant.

Uvularia grandiflora Sm. *Bellwort.* Woods, I3 Q1 R1 S8.

*Yucca smalliana Fern. (Y. filamentosa) *Spanish bayonet.* Escape, edge of grazed woods, Fulton 23 NE.

Zigadenus elegans Pursh var. glaucus (Nutt.) Preece. *White camass, alkali grass.* Dry prairie, G2.

DIOSCOREACEAE (Yam Family)

Dioscorea villosa L. *Wild yam.* Low woods, O1 Q1 T3 T5.

AMARYLLIDACEAE (Amaryllis Family)

Hypoxis hirsuta (L.) Cov. *Yellow stargrass.* Prairies, open woods, J4 L2 N1 O4 P3 S1 T3.

IRIDACEAE (Iris Family)

Iris virginica L. var. shrevei (Small) E. Anders. *Blueflag.* Marshes, ditches, F2 L2 O2 O4 O5 R1 S1 T3 T5 T8.

Sisyrinchium campestre Bickn. *Blue-eyed grass.* Prairies, C1 G1 G2 I1 J4 L2 M2 N1 P5 S1; common.

ORCHIDACEAE (Orchid Family)

Aplectrum hyemale (Muhl.) Torr. *Puttyroot.* Case, 1964.

Arethusa bulbosa L. *Swamp pink.* Edgerton (*Sylvester,* 1884, MIL).

Calopogon tuberosus (L.) BSP. (C. pulchellus) *Grass pink.* Shallow "bog," Avon 23 (*Fell,* 1957, WIS).

Corallorhiza maculata Raf. *Spotted coralroot.* Sandy woods, L1.

C. odontorhiza (Willd.) Nutt. *Late coralroot.* Woods, S9, one plant (! Peet).

Cypripedium acaule Ait. *Moccasin flower.* Sphagnum bog, E1.

C. calceolus L. var. pubescens (Willd.) Correll. *Yellow ladyslipper.* Woods, H1 I3 R1 S8 T7, Newark 5.

C. candidum Muhl. *Small white ladyslipper.* Fen, L2.

Goodyera pubescens (Willd.) R. Br. *Rattlesnake plantain.* Woods, H1 T7.

Habenaria leucophaea (Nutt.) Gray. *Prairie white-fringed orchid.* Low prairie, S1.

H. psycodes (L.) Spreng. *Purple-fringed orchid.* Sphagnum bog, E1.

H. viridis (L.) R. Br. var. bracteata (Muhl.) Gray. *Rein orchid.* Janesville (*Mead & Blunt,* 1930, WIS).

Liparis liliifolia (L.) Rich. *Purple twayblade.* Woods, B1 H1.

L. loeselii (L.) Rich. *Yellow twayblade.* Sphagnum bog, E1; low prairie, O2.
Orchis spectabilis L. *Showy orchid.* Woods, Q1, S8 (! Peet).
Pogonia ophioglossoides (L.) Ker. *Rose pogonia, snakemouth.* Floating bog mat, Milton 17 E (! photo Bachay).
Spiranthes cernua (L.) Rich. *Ladies' tresses.* Low prairies, E1 H1 L2 R2 S2.

SALICACEAE (Willow Family)

*Populus alba L. *White poplar.* Spreading along roadsides, La Prairie 24, Rock 24; infrequent.
*P. candicans Ait. *Balm-of-Gilead.* Beloit (*Olds,* 1893, WIS).
P. deltoides Marsh. *Cottonwood.* Streams, marshes, C2 H3 O3 N2 T3 T5.
P. grandidentata Michx. *Large-toothed aspen.* Woods, H1 R1; railroad embankment, I2.
*P. nigra L. cv. *'italica.' Lombardy poplar.* Spreading from cult., Rock 11.
P. tremuloides Michx. *Trembling aspen.* Open woods, fencerows, prairies, H2 L3 P3 P5 Q1 R1 S3 T3 T6 T7; common.
*Salix alba L. *White willow.* Beloit (*Olds,* 1893, WIS).
S. amygdaloides Anderss. *Peach-leaved willow.* Prairie margins, S1 T3.
*S. babylonica L. *Weeping willow.* Escape, low woods, C2.
S. bebbiana Sarg. *Beaked willow.* Sphagnum bogs, A1 E1; wet thickets, H3 J4 L2 M4 O2 O3 S3; common.
S. candida Flügge. *Sage-leaved willow.* Sphagnum bog, E1; wet alkaline prairies, O2 O3 S2.
S. discolor Muhl. *Pussywillow.* Streamsides, ditches, A5 B1 H3 J4 L2 O2 R1 S1 T8; common.
*S. fragilis L. *Crack willow.* Streamside, Clinton 17 N (*Fell,* 1957, WIS).
S. glaucophylloides Fern. *Dune willow.* Prairie, L2, one plant.
S. humilis Marsh. (Incl. S. tristis) *Prairie willow.* Prairies, I1 J4 L2 L4 S1 S4; wooded slope, J1; common.
S. interior Rowlee. *Sandbar willow.* Shores, streams, A4 B1 D4 E4 L3 O3 O6 P4 R1 T3 T5.
S. lucida Muhl. *Shining willow.* Streamsides. Var. lucida: S5 (*Fassett,* 1928, WIS). Var. intonsa Fern.: R1.
S. nigra L. *Black willow.* Streams, C2 H1 T3 T4 T5 T8; common.
S. pedicellaris Pursh. *Bog willow.* Sphagnum bogs, A1 E1.
S. petiolaris Sm. *Slender willow.* Low prairies, J4 L2 S1; shores, A3 A5.
*S. purpurea L. *Purple willow* or *osier.* Riverbank, R1 (*Anthoney,* 1932, WIS).
S. rigida Muhl. *Heart-leaved willow.* Low prairies, J4 L2 L3 R1 T3; shore, A1; common.
S. sericea Muhl. *Silky willow.* Beloit (*Lathrop, s. d.,* WIS).
S. serissima (Bailey) Fern. *Autumn willow.* Sphagnum bog, E1; prairie, O2.

JUGLANDACEAE (Walnut Family)

Carya cordiformis (Wang.) K. Koch. *Bitternut.* Woods, H1 J1 O1 O3 P1 Q1 R1 S1 T5; common.
C. ovata (Mill.) K. Koch. *Shagbark hickory, shellbark.* Upland woods, very common throughout.
Juglans cinerea L. *Butternut.* Moist woods, H3 M5 O3 R1; frequent.
J. nigra L. *Black walnut.* Rich woods, common.

BETULACEAE (Birch Family)

Alnus rugosa (DuRoi) Spreng. var. americana (Regel) Fern. *Speckled alder.* Shrub-carr, Avon 36.
Betula lutea Michx. f. (B. alleghaniensis) *Yellow birch.* Wooded sandstone slopes, J1 J3, solitary plants.
B. papyrifera Marsh. *White birch.* N-facing sandstone slopes, J1 K2, locally abundant.
B. pumila L. var. glandulifera Regel (B. glandulosa g.) *Swamp birch.* Sphagnum bog, E1; low prairies, fens, H3 J4 O2 S3 S6.

B. Xsandbergii Britt. (B. papyrifera X B. pumila glandulifera) *Sandberg's birch.*. Sphagnum bog, E1; low prairie, O2.

Carpinus caroliniana Walt. *Hornbeam, blue beech.* Wooded limestone slopes, C3 H4 O1.

Corylus americana Walt. *Hazel.* Woods, thickets, prairies, very common.

Ostrya virginiana (Mill.) K. Koch. *Ironwood, hop hornbeam.* Woods, streamsides, C2 H2 H3 H4 M5 O1 Q1 R1.

FAGACEAE (Beech Family)

Quercus alba L. *White oak.* Upland woods, very common dominant.

Q. bicolor Willd. *Swamp white oak.* Low woods, M3 T3 T5.

Q. borealis Michx. f. var. maxima (Marsh.) Ashe. *Red oak.* Mesic woods, very common dominant.

Q. ellipsoidalis E. J. Hill. *Jack* or *Hill's oak.* Sandy slope, L1.

Q. macrocarpa Michx. *Bur oak.* Prairie borders, upland woods, very common. Our most characteristic and beautiful tree.

Q. muhlenbergii Engelm. (Q. prinoides acuminata) *Chinquapin oak.* Dry limestone slopes, O3 (! Peet) R1.

Q. velutina Lam. *Black oak.* Dry sandy soil, common, often dominant.

ULMACEAE (Elm Family)

Celtis occidentalis L. *Hackberry.* Woods, H2 K2 Q1 S4 S8 T3 T4 T5.

Ulmus americana L. *American elm.* Moist soil, very common throughout.

*U. pumila L. *Siberian elm.* Railroad, N1, one tree.

U. rubra Muhl. *Slippery elm.* Rich woods, H1 I1 I3 J1 K2 M5 O1 O3 P5 Q1 S5 T3 T5 T6 T7.

U. thomasii Sarg. *Rock* or *cork elm.* Beloit (*Olds,* 1893, WIS).

MORACEAE (Mulberry Family)

*Cannabis sativa L. *Hemp, marijuana.* Roadsides, pastures, L3 M2 O3 O4 T3.

*Humulus lupulus L. *Hops.* Railroad, E5; fencerow, Newark 34.

*Maclura pomifera (Raf.) Schneid. *Osage orange.* Spreading from cult., fencerow, Newark 14 N.

*Morus alba L. *White mulberry.* Disturbed sites, H1 J1 M5 R1.

M. rubra L. *Red mulberry.* Streamsides, O3 R1 T3.

URTICACEAE (Nettle Family)

Boehmeria cylindrica (L.) Sw. *False nettle.* Low open woods, T3 T5; sphagnum bog, E1; frequent.

Laportea canadensis (L.) Wedd. *Wood nettle.* Low rich woods, H2 T3 T5; frequent.

Parietaria pensylvanica Muhl. *Pellitory.* Mesic woods, H2 K3; common.

Pilea fontana (Lunell) Rydb. *Clearweed, coolwort.* Swampy pond margin, Milton 6 (*Iltis & Janecek,* 1956, WIS).

P. pumila (L.) Gray. *Dwarf clearweed.* Ditch, H2; sphagnum bog, E1; woods, H4 T3 T5; common.

Urtica dioica L. var. procera (Muhl.) Wedd. (Incl. U. gracilis) *Nettle.* Woods, fencerows, low pastures, E4 M5 O3 P6 Q2 T3 T5 T8; common.

SANTALACEAE (Sandalwood Family)

Comandra umbellata (L.) Nutt. (Incl. C. richardsiana) *Bastard toadflax.* Prairies, dry woods, very common.

ARISTOLOCHIACEAE (Birthwort Family)

Asarum canadense L. *Wild ginger.* Rich woods, H2 O3 R1. Var. acuminatum Ashe: H3 O1. Var. reflexum (Bickn.) Robins.: T3 T5.

POLYGONACEAE (Buckwheat Family)

*Fagopyrum esculentum Moench (F. sagittatum) *Buckwheat.* RR yard, P3 (*Fell,* 1957, WIS).

*Polygonum arenastrum Bor. *Sand knotweed.* Mudflat, E7; common.
*P. aviculare L. *Common knotweed.* Roadsides, streets, cult. ground, L3; common.
P. buxiforme Small (P. aviculare littorale) *Knotweed, doorweed.* Roadside, Newark 32 (*Fell,* 1957, WIS). (Det.: T. R. Mertens, 1966).
P. careyi Olney. *Carey's smartweed.* Wet meadow, O2.
P. coccineum Muhl. *Water smartweed.* Wet ground, shallow water, E1 E4 E8 P3 P5.
*P. convolvulus L. *Black bindweed.* Thicket, Avon 34 (*Fell,* 1957, WIS).
*P. cuspidatum Sieb. & Zucc. *Mexican bamboo.* Ditch, Porter 9 NW.
P. hydropiper L. *Water pepper.* Wet ground, E1 O3 O5 Q2 T8.
P. hydropiperoides Michx. *Mild water pepper.* Drainage ditch, Avon 24 (*Fell,* 1957, WIS).
P. lapathifolium L. *Heart's ease.* Wet or damp areas, D7 E7 O3; frequent.
P. natans Eat. (P. amphibium) *Water smartweed.* Sloughs, B1 T3 T5.
*P. orientale L. *Prince's feather.* Railroad, E5.
P. pensylvanicum L. var. laevigatum Fern. *Pinkweed.* Damp ground, D7 E1 O4 O7 Q2 S7 T3 T5; common.
*P. persicaria L. *Lady's thumb.* Damp open ground, P5 S1.
P. punctatum Ell. var. confertiflorum (Meisn.) Fassett. *Water smartweed.* Marsh, O2; sphagnum bog, E1.
P. sagittatum L. *Tear-thumb.* Wet ground, E1 M3 O4 R1 T3 T5.
P. scandens L. *False buckwheat.* Damp open ground, P3 Q5.
P. tenue Michx. *Slender knotweed.* Sandy slopes, I1 J1 J2 J3 L1 S4.
P. virginianum L. (Tovara v.) *Jumpseed.* Damp woods, Q5 T3 T5.
*Rheum rhaponticum L. *Rhubarb.* Escape, roadside, Beloit 17.
*Rumex acetosella L. *Sheep sorrel.* Weed of poor soil, J1 L1 M5 P1 R1 R2 R3 T1; common.
R. altissimus Wood. *Pale dock.* Weed of deep soil, P3 P6; infrequent.
*R. crispus L. *Sour* or *curly dock.* Ubiquitous weed.
R. maritimus L. var. fueginus (Phil.) Dusén. *Golden dock.* Marshy shore, A3.
R. mexicanus Meisn. *Mexican dock.* Weed of rich soil, P6 Q2 R1.
*R. obtusifolius L. *Bitter dock.* Damp shaded roadside, H2.
R. orbiculatus Gray. *Great water dock.* Wet meadows, E1 L3 O2.
R. verticillatus L. *Swamp dock.* Sphagnum bogs, A1 E1; shore, R1.

CHENOPODIACEAE (Goosefoot Family)

Atriplex patula L. *Spearscale.* Var. patula: Ellis Woods, Union NW (*Iltis & Ugent,* 1961, WIS). Var. hastata (L.) Gray: fencerow, N3 (*Wickham,* 1947, WIS).
*Chenopodium album L. *Lamb's quarters.* Both vars. album and lanceolatum (Muhl.) Coss. & Germ. are ubiquitous weeds.
*C. ambrosioides L. *Wormseed.* Beloit (*Hale,* 1861, WIS).
C. berlandieri Moq. var. zschackei (Murr.) Murr. *Berlandier's goosefoot.* Ellis Woods, Union NW (*Iltis & Ugent,* 1961, WIS).
*C. botrys L. *Jerusalem oak.* Janesville (*Finger, s. d.,* MIL).
C. bushianum Aellen. *Bush's pigweed.* Marsh margin, D7 (*Mori,* 1965, WIS).
C. desiccatum Nels. var. leptophylloides (Murr.) Wahl. *Narrow-leaved goosefoot.* Roadside, Center 20 (*McCarten,* 1965, WIS).
C. gigantospermum Aellen (C. hybridum) *Maple-leaved goosefoot.* Open woods, Q1.
C. standleyanum Aellen. *Woodland goosefoot.* Creekbottom, O3 (*Fell,* 1957, WIS).
C. strictum Roth var. glaucophyllum (Aellen) Wahl. *Erect goosefoot.* Railroad yard, P3 (*Fell,* 1957, WIS).
*Kochia scoparia (L.) Schrad. *Summer cypress.* Alley, Edgerton (*Thomson,* 1943, WIS); infrequent.
*Salsola kali L. var. tenuifolia G. F. W. Mey. *Russian thistle.* Railroad, R1.

AMARANTHACEAE (Amaranth Family)

Amaranthus albus L. *Tumbleweed.* Fields, roadsides, M5, Avon 34; frequent.

*A. arenicola Johnst. *Amaranth.* Beloit (*Shinners 4647,* 1942, WIS). Only Wisconsin collection.

A. graecizans L. *Creeping amaranth* or *tumbleweed.* Lawn weed, Q1.

*A. hybridus L. *Green amaranth.* Cult. ground, O5; infrequent.

*A. hypochondriacus L. *Amaranth.* Beloit (*Anthoney,* 1936, WIS).

*A. powellii S. Wats. *Smooth pigweed.* Cornfield, Fulton 12 N (*Sauer,* 1956, WIS).

*A. retroflexus L. *Rough amaranth.* Wet soil, O7 Q2 T3 T5; common.

A. tuberculatus (Moq.) Sauer (Acnida altissima) *Water hemp.* Wet areas, D7 E7 O2 O4 O5 S7 T3.

Froelichia gracilis (Hook.) Moq. *Cottonweed.* Sauer & Davidson, 1961.

NYCTAGINACEAE (Four-O'Clock Family)

*Mirabilis nyctaginea (Michx.) MacM. (Oxybaphus nyctagineus) *Wild four-o'clock.* Weed, often on railroads, H1 L2 M1 N1 P3 P5 P6 R1; common.

PHYTOLACCACEAE (Pokeweed Family)

*Phytolacca americana L. *Pokeweed.* Building site, Q5.

AIZOACEAE (Carpetweed Family)

*Mollugo verticillata L. *Carpetweed.* Sand, J1 J2, Newark 27.

PORTULACACEAE (Purslane Family)

Claytonia virginica L. *Spring beauty.* Woods, O1 O3 O4 Q1 R1.

*Portulaca oleracea L. *Purslane.* Weed, especially of cult. ground and streets, very common.

Talinum rugospermum Holz. *Fameflower.* Sandstone outcrops, J1 J2; gravel pit, M7, one plant.

CARYOPHYLLACEAE (Pink Family)

*Agrostemma githago L. *Corn cockle.* Janesville (*Skavlem,* 1889, WIS). Once common, now very rare in the absence of rye fields.

Arenaria lateriflora L. *Grove sandwort.* Open woods, J1 M6 Q1 R1 T1 T5 T6; low prairies, E2 L1 L2 O4 P2 P3 T3.

*A. serpyllifolia L. *Thyme-leaved sandwort.* Beloit (*Olds,* 1896, WIS).

A. stricta Michx. ssp. stricta. *Rock sandwort.* Dry gravelly prairies, B2 C1 I1 M2 O4 R2; rock ledges, J1 T7; common.

Cerastium arvense L. var. oblongifolium (Torr.) Holl. & Britt. *Field chickweed.* Beloit (*Swezey,* 1875, WIS).

*C. fontanum Baumg. (C. vulgatum) *Mouse-ear chickweed.* Ubiquitous weed.

*Dianthus barbatus L. *Sweet William.* Janesville (*Skavlem,* 1889, WIS).

*D. deltoides L. *Maiden pink.* Beloit (*Olds,* 1895, WIS).

*D. plumarius L. *Garden pink.* Janesville (*Skavlem,* 1889, WIS).

*Lychnis alba Mill. *White campion.* Fields, roadsides, very common.

Paronychia canadensis (L.) Wood. *Forked chickweed.* Janesville (*Watson,* 1860, ULJ).

*Saponaria officinalis L. *Bouncing Bet, soapwort.* Roadsides, railroads, P3 P5 Q2; common.

*S. vaccaria L. (Vaccaria segetalis) *Cow herb.* Beloit (*Collector unknown,* 1884, WIS).

*Silene antirrhina L. *Sleepy catchfly.* Sandy or gravelly soil, J1 R1; frequent.

*S. cserei Baumg. *Smooth campion.* Railroad embankments, A5 P3.

*S. cucubalus Wibel. *Bladder campion.* Railroads, P5 P6; frequent.

*S. dichotoma Ehrh. *Forked catchfly.* Roadside, R2 (*Fell,* 1957, WIS).

S. nivea (Nutt.) Otth. *Snowy campion.* Lowland, S3 (*Fell,* 1957, WIS); infrequent.

*S. noctiflora L. *Night-flowering catchfly.* Janesville (*Skavlem,* 1889, WIS).

S. stellata (L.) Ait. f. var. scabrella (Nieuw.) Palm. & Steym. *Starry campion.* Woods, H1 J1 L1 O1 T7, local.

*Stellaria aquatica (L.) Scop. (Myosoton aquaticum) *Chickweed.* Mesic woods, O1 Q1 Q2; frequent.

*S. graminea L. *Starwort.* Grassy area, R1 (*Anthoney,* 1932, WIS).

S. longifolia Muhl. var. longifolia. *Stitchwort.* Sedge meadows, E1 O2.
*S. media (L.) Vill. *Common chickweed.* Ubiquitous weed.

CERATOPHYLLACEAE (Hornwort Family)

Ceratophyllum demersum L. *Coontail.* Lakes, D4 D7; sloughs, T3 T5; common.

NYMPHAEACEAE (Waterlily Family)

Nuphar variegatum Engelm. *Spatterdock.* Stream, N2; sloughs, T3 T5.
Nymphaea odorata Ait. *Fragrant waterlily.* Lakes, D4 D7 D8; stream, N2.
N. tuberosa Paine. *White waterlily.* Creek, Turtle 3 SE (*Fell,* 1957, WIS). Identification requires field verification.

RANUNCULACEAE (Crowfoot Family)

Actaea pachypoda Ell. (A. alba) *White baneberry.* Woods, 13 O4.
A. rubra (Ait.) Willd. *Red baneberry.* Woods, O4 P7 R1.
Anemone canadensis L. *Meadow anemone.* Low prairies, J4 L2 O4 P3 P5 P6 Q1 R2 S1; common.
A. cylindrica Gray. *Slender thimbleweed.* Dry prairies, open woods, B2 E1 E5 H1 L1 N1 P3 P5 P6.
A. patens L. var. wolfgangiana (Bess.) Koch. *Pasque flower.* Dry calcareous prairies, B2 C1 D5 G1 G2 H1 11 M2 R2 T2 T4.
A. quinquefolia L. var. bifolia Farwell (A. q. interior) *Wood anemone.* Woods, H2 J1 O1 O3 P1 P2 P7 Q1 R1 S8 S9 T1 T6.
A. riparia Fern. *River thimbleweed.* Woods, R1 (*Anthoney,* 1932, WIS); infrequent.
A. virginiana L. *Tall thimbleweed.* Wooded bluff, O4 (*Fell,* 1957, WIS); infrequent.
Anemonella thalictroides (L.) Spach. *Rue anemone.* Woods, H2 O1 O4 Q1 R1 S8.
Aquilegia canadensis L. *Columbine.* Shaded limestone, C3 H2 J1 L1 O1 O3 O4 R1 T1.
Caltha palustris L. *Marsh marigold.* Marshes, springs, streamsides, A1 B1 D1 E1 H3 J4 L2 O2 P3 R1 S1 S2 S3 S7 T3.
Clematis virginiana L. *Virgin's bower.* Low woods, Q2 R1 T3 T5.
*Delphinium ajacis L. *Rocket larkspur.* Janesville (*Skavlem,* 1889, WIS).
Hepatica acutiloba DC. *Sharp-lobed hepatica.* Woods, O1 O3 O4 Q1 R1.
H. americana (DC.) Ker. *Round-lobed hepatica.* Wooded slopes, E1, Magnolia 15.
Hydrastis canadensis L. *Golden seal.* Burdick-Salisbury Woods, Milton (*Bergseng, Salisbury, & Cull,* 1945, WIS). Site now destroyed.
Isopyrum biternatum (Raf.) T. & G. *False rue anemone.* Woods, O1 O3 O4 Q1 R1.
Ranunculus abortivus L. *Small-flowered buttercup.* Moist woods, H2 H3 O1 O4 P1 P2 P7 Q1 R1 T1 T3 T5.
*R. acris L. *Tall buttercup.* Low fields, clearings, L4 P3 R1.
R. aquatilis L. var. capillaceus (Thuill.) DC. (R. trichophyllus) *White water crowfoot.* Stream, E5.
R. fascicularis Muhl. *Early buttercup.* Dry open woods, dry prairies, B2 G2 J1 M2 L1 O1 P1 P2 R2 T6 T7.
R. flabellaris Raf. *Yellow water crowfoot.* Shallow water, E1 E2 T3.
R. longirostris Godr. (R. circinatus) *Stiff water crowfoot.* Quiet water, A4 E5 E7, locally abundant.
R. pensylvanicus L. f. *Bristly crowfoot.* Mud, D7 D8 S8.
R. recurvatus Poir. *Hooked crowfoot.* Low woods, D4 O4 P2 P7 T3 T5.
R. rhomboideus Goldie. *Prairie buttercup.* Prairies, L2 M2.
R. sceleratus L. *Cursed crowfoot.* Shores, sloughs, A3 A4 D8 T3.
R. septentrionalis Poir. *Swamp buttercup.* Damp woods, H2 M6 P7 Q1 R1 S9 T5.
Thalictrum dasycarpum Fisch. & Lall. *Purple* or *tall meadow rue.* Low prairies, sedge meadows, shrub-carrs. Var. dasycarpum: very common throughout. Var. hypoglaucum (Rydb.) Boivin: P4, Avon 26.
T. dioicum L. *Early meadow rue.* Woods, O4 R1 S8.
T. revolutum DC. var. glandulosius Boivin. *Waxy meadow rue.* Low prairies, P1 P3.

BERBERIDACEAE (Barberry Family)

*Berberis thunbergii DC. *Japanese barberry.* Woods, H1 H2 J1 L1 M5 O4 Q1.

Caulophyllum thalictroides (L.) Michx. *Blue cohosh.* Woods, O3 Q1 R1 S8.

Podophyllum peltatum L. *May apple, mandrake.* Rich woods, persisting in wooded pastures, J1 L1 O1 O3 O4 P5 Q1 R1 S8 S9 T7.

MENISPERMACEAE (Moonseed Family)

Menispermum canadense L. *Moonseed.* Low woods, K2 O2 T3 T5.

PAPAVERACEAE (Poppy Family)

Sanguinaria canadensis L. *Bloodroot.* Rich woods, H2 O1 O3 O4 R1.

FUMARIACEAE (Fumitory Family)

Corydalis aurea Willd. ssp. aurea. *Golden corydalis.* Limestone bank along Rock River, C3.

C. micrantha (Engelm.) Gray ssp. micrantha. *Fumewort.* Gravel, railroad cut, Turtle 31 (*Fassett & Meyer,* 1928, WIS).

Dicentra canadensis (Goldie) Walp. *Squirrel corn.* Rich woods, O3.

D. cucullaria (L.) Bernh. *Dutchman's breeches.* Rich woods, H2 O1 O3 O4 Q1 R1 T5.

CRUCIFERAE (Mustard Family)

*Alyssum alyssoides L. *Alyssum.* Gravel pits, M7, La Prairie 6.

*Arabidopsis thaliana (L.) Heyn. *Mouse-ear cress.* Railroad, L2 (! Musselman). Second Wisconsin record, both reports from 1969.

Arabis canadensis L. *Sicklepod.* Woods, O4.

A. divaricarpa Nels. *Rock cress.* Dry prairie, M1.

A. glabra (L.) Bernh. *Tower mustard.* Meadow, Newark 27 (*Shinners & Catenhusen,* 1942, WIS).

A. hirsuta (L.) Scop. *Hairy rock cress.* Var. adpressipilis (Hopkins) Rollins; gravel, M7. Var. pycnocarpa (Hopkins) Rollins: Beloit (*Olds,* 1895, WIS).

A. laevigata (Muhl.) Poir. *Bank cress.* Woods, C3 H2 O1 R1.

A. lyrata L. *Sand cress.* Dry sandstone, T1.

A. shortii (Fern.) G1. (A. perstellata s.) *Toothed cress.* Low woods, T3 T5.

*Armoracia rusticana Gaertn., Mey., & Scherb. (A. lapathifolia) *Horseradish.* Roadside, Newark 4 N.

*Barbarea vulgaris R. Br., *sensu lato. Yellow rocket, winter cress.* Fields, roadsides, meadows, streambanks, very common.

*Berteroa incana (L.) DC. *Hoary alyssum.* Sandy or gravelly soil, very common.

*Brassica juncea (L.) Coss. *Brown mustard.* Low woods, C2.

*B. kaber (DC.) L. Wheeler var. pinnatifida (Stokes) L. Wheeler. *Charlock.* Fencerow, N3 (*Wickham,* 1947, WIS).

*B. nigra (L.) Koch. *Black mustard.* Fields, roadsides, railroads, C2 P3 R1; common.

*Camelina microcarpa Andrz. *False flax.* Railroad, Turtle 21 E (*Shinners,* 1942, WIS).

*Capsella bursa-pastoris (L.) Medic. *Shepherd's purse.* Ubiquitous weed.

Cardamine bulbosa (Muhl.) BSP. *Spring cress.* Marshes, springs, wet woods, H3 L2 O2 P7 R1 R2 S1 T3 T5; common.

C. pensylvanica Muhl. *Bitter cress.* Low woods, T5.

Dentaria laciniata Muhl. *Toothwort.* Woods, D7 O1 O3 O4 Q1 R1.

Descurainia pinnata (Walt.) Britt. var. brachycarpa (Richards.) Fern. *Tansy mustard.* Railroads, J4 L4 P3, locally abundant.

*D. sophia (L.) Webb. *Herb-Sophia.* Dry gravelly prairie, Turtle 31.

Draba reptans (Lam.) Fern. *Whitlow grass.* Dry sands, M1 T1 T2, Avon 7, locally abundant.

*Erysimum cheiranthoides L. *Wormseed* or *treacle mustard.* Riverbanks, prairies, fields, roadsides, N1 T5; frequent.

E. inconspicuum (S. Wats.) MacM. *Small wormseed mustard.* Railroad, R2 (*Anthoney,* 1936, WIS).

*Hesperis matronalis L. *Dame's violet.* Roadsides, H2, Magnolia 8.
*Lepidium campestre (L.) R. Br. *Field cress.* Fields, roadsides, railroads, O1 O4 P5 T1; common.
*L. densiflorum Schrad. *Small peppergrass.* Dry soil, very common.
L. virginicum L. *Common peppergrass.* Along stream, Turtle 10 E (*Wickham,* 1947, WIS).
*Nasturtium microphyllum Boenn. *Small-leaved watercress.* River, Porter 10 (*Blanchard,* 1960, WIS). (Det.: Ronald L. Stuckey, 1965).
*N. officinale R. Br. *Watercress.* Springs, streams, D6 E3 H3 O1 O2 O3 T3 T5.
*N. Xsterilis (Shaw) Stuckey (N. officinale X N. microphyllum) *Watercress.* Riverbank, Janesville 5 (*Green,* 1947, WIS). (Det.: Ronald L. Stuckey, 1965).
*Raphanus raphanistrum L. *Wild radish.* Plowed field, Q1.
*Rorippa austriaca (Crantz) Bess. *Yellow cress.* Low prairie, O2; weedy field, Q2 (*Rice & Rice 3026, Rice 4064,* 1970, ULJ). Known previously in Wisconsin only from Madison.
R. islandica (Oeder) Borbas var. fernaldiana Butters & Abbe. *Marsh cress.* Sloughs, O4 S1 T3; shore, A3; common.
*R. sylvestris (L.) Bess. *Creeping yellow marsh cress.* Kettle-pond, Newville (*Thomson,* 1938, WIS).
*Sisymbrium altissimum L. *Tumble mustard.* Fields, roadsides, railroads, P5 Q7 R1; frequent.
*S. officinale (L.) Scop. var. leiocarpum DC. *Hedge mustard.* Weed, R2; infrequent.
*Thlaspi arvense L. *Penny cress.* Fields, roadsides, railroads, A1 M7 P4 P5; common.

CAPPARIDACEAE (Caper Family)

Polanisia dodecandra (L.) DC. ssp. dodecandra (P. graveolens) *Clammyweed.* Railroad ballast, N1, Plymouth 14 N, Spring Valley 21.

RESEDACEAE (Mignonette Family)

*Reseda lutea L. *Mignonette.* Railroad ballast, L4 (*Musselman s. n.,* 1964, UWM). Second Wisconsin collection.

SARRACENIACEAE (Pitcher Plant Family)

Sarracenia purpurea L. *Pitcher plant.* Sphagnum bog, E1, locally abundant.

DROSERACEAE (Sundew Family)

Drosera rotundifolia L. *Sundew.* Sphagnum bog, E1.

CRASSULACEAE (Orpine Family)

Penthorum sedoides L. *Ditch stonecrop.* Marshes, springs, sloughs, ditches, D3 L2 O2 O4 O6 R1 S2 S3 S6 S7 T3 T5.
*Sedum acre L. *Wall pepper, stonecrop.* Rocky slope, J2.
*S. sarmentosum Bunge. *Stringy stonecrop.* Limestone cliff, C3.
*S. telephium L. (S. purpureum) *Live-forever.* Rocky slope, J2; railroad, P6.

SAXIFRAGACEAE (Saxifrage Family)

Heuchera richardsonii R. Br., *sensu lato. Alumroot.* Prairies, open woods, very common.
Mitella diphylla L. *Bishop's cap.* Rocky woods, H2 O1 O3 O4 R1.
Parnassia glauca Raf. *Grass-of-Parnassus.* Fens, marshes, D3 H3 L2 O2; sphagnum bog, E1; railroad, Rock 3.
Ribes americanum Mill. *Wild black currant.* Low woods, shrub-carrs, thickets, H3 O2 P1 P7 T3 T5; sphagnum bog, E1.
R. cynosbati L. *Dogberry.* Woods, H2 J1 K2 L1 M5 P1 P3; common.
R. missouriense Nutt. *Missouri gooseberry.* Open woods, fencerows, H2 H3 J1 K2 L1 M4 Q1 S4; common.
*R. odoratum Wendl. *Clove* or *golden currant.* Escape, P5 T4, Beloit 4 E, Turtle 2 NW.

*R. sativum Syme. *Garden* or *red currant.* Oak woods, Beloit (*Fassett,* 1928, WIS).

Saxifraga pensylvanica L., *sensu lato. Swamp saxifrage.* Low prairies, fens, shrub-carrs, D3 E1 H3 L2 O2 S1 S3; common.

PLATANACEAE (Plane-tree Family)

Platanus occidentalis L. *Sycamore.* Bottomlands, M5 T3 T5, local.

ROSACEAE (Rose Family)

Agrimonia gryposepala Wallr. *Tall cocklebur.* Woods, D7 R1; frequent.

A. parviflora Ait. *Swamp agrimony.* Grazed low prairie, O2 (*Rice 3119,* 1970, ULJ, WIS). First Wisconsin collection.

A. pubescens Wallr. *Soft agrimony.* Dry woods, J1 O1; common.

Amelanchier arborea (Michx. f.) Fern. *Downy juneberry.* Limestone, M4.

A. interior Nielsen. *Inland serviceberry.* Sandstone slopes, J1 L1.

A. laevis Wieg. *Allegheny shadblow.* Woods, O1 (*Fell,* 1957, WIS).

A. sanguinea (Pursh) DC. *Round-leaved serviceberry.* N-facing sandstone slope, J1; savanna, Spring Valley 5.

A. spicata (Lam.) K. Koch. *Serviceberry.* Limestone slope, H2; frequent.

Aronia melanocarpa (Michx.) Ell. *Black chokeberry.* Sandstone, J3 L1 T1 T6 T7; frequent.

A. prunifolia (Marsh.) Rehd. *Purple chokeberry.* Sphagnum bog, E1.

Crataegus chrysocarpa Ashe (C. rotundifolia *sensu* Gleas. & Cronq.) *Round-leaved hawthorn.* Low woods, T3.

C. faxonii Sarg. var. praecoqua (Sarg.) Kruschke (C. rotundifolia *sensu* Gleas. & Cronq.) *Faxon's hawthorn.* Grazed hillside, Lima 10.

C. macracantha Lodd. (C. succulenta m.) *Hawthorn.* Low woods, R1 T3.

C. mollis (T. & G.) Scheele. *Downy hawthorn.* Woods, R1 T3 T5; low pasture, M7; common.

*C. oxyacantha L. *Hawthorn.* Woods, T7, Porter 9.

C. pruinosa (Wendl.) K. Koch. *Frosted hawthorn.* Woods, J1.

C. punctata Jacq. *Dotted hawthorn.* Woods, Beloit (*Anthoney,* 1932, WIS).

C. succulenta Link. *Fleshy hawthorn.* Disturbed woods, Newark 1 C.

Fragaria vesca L. ssp. americana (Port.) St. *Wood strawberry.* Open woods, O4; infrequent.

F. virginiana Duchesne ssp. virginiana. *Wild strawberry.* Woods, fields, railroads, very common.

Geum aleppicum Jacq. *Yellow avens.* Woods, H4 L1; low prairie, L4.

G. canadense Jacq. *White avens.* Damp woods, K2 O1 S8 T3 T5.

G. laciniatum Murr. *Rough avens.* Moist thicket, A4; roadside, S6; railroad, P3; frequent.

G. triflorum Pursh. *Prairie smoke.* Dry or moist alkaline prairies, C1 D5 G1 G2 H1 I1 L2 M2 M3 R2 S1 T2.

*G. vernum (Raf.) T. & G. *Spring* or *early water avens.* Lane, mesic woods, Q1 (*Cochrane 527,* 1969, WIS). Second Wisconsin collection.

Physocarpus opulifolius (L.) Maxim. *Ninebark.* Wooded limestone, J1 O1 O3 T6; frequent. Var. opulifolius: R1. Var. intermedius (Rydb.) Robins.: damp thicket, Union 22.

Potentilla anserina L. *Silverweed.* Beloit (*Collector unknown,* 1857, WIS).

*P. argentea L. *Silvery cinquefoil.* Dry prairies, I2 M2 R2; roadside, O1; frequent.

P. arguta Pursh. *Tall cinquefoil.* Dry prairies, open woods, B2 D5 G2 H1 N1 O1 P4 R2 T1; common.

P. fruticosa L. (P. floribunda) *Shrubby cinquefoil.* Wet meadow, O2, one plant.

P. norvegica L. *Rough cinquefoil.* Fields, pastures, roadsides, railroads, H1 P1 P5 S1 S3 S7 T3; common.

P. palustris (L.) Scop. *Marsh five-finger.* Sphagnum bogs, A1 E1, locally abundant.

*P. recta L. *Sulfur cinquefoil.* Weed of dry soil, I1 I2 J1 O1 O2 O4 M5 P5 R2; common.

P. simplex Michx. *Common cinquefoil.* Dry open woods, prairies, embankments, very common.

Prunus americana Marsh. *Wild plum.* Roadsides, fencerows, D5 L1 O7 R1; frequent.

P. nigra Ait. *Canada plum.* Sandy oak opening, L1.

P. pensylvanica L. f. *Pin cherry.* Open area, dry sandy soil, Avon 21 (*Boebel & Laube,* 1964, WIS); infrequent.

*P. persicaria (L.) Batsch. *Peach.* Dump along river, Fulton 16.

P. pumila L., *sensu lato. Sand cherry.* Sandy or gravelly prairies, G2 I1 I2 J1 T2.

P. serotina Ehrh. *Black cherry.* Woods, fencerows, very common.

P. virginiana L. *Choke cherry.* Open woods, thickets, fencerows, E5 J1 O2 Q1 R1 T7; common.

Pyrus ioensis (Wood) Carruth. *Wild* or *Iowa crab.* Open woods, fencerows, M1 M8 O2 O3 Q1 T3, Plymouth 20.

*P. malus L. (Malus pumila) *Apple.* Escape, H1 M7; infrequent.

Rosa acicularis Lindl. *Prickly wild rose.* Prairie, L2.

R. arkansana Porter var. suffulta (Greene) Cockerell. *Prairie wild rose.* Railroads, L1 P3 P5 P6; common.

R. blanda Ait. *Early wild rose.* Prairies, P3 R1 R2; common.

R. carolina L. *Pasture rose.* Railroads, P3 P5; sandstone outcrop, Avon 3.

R. Xdulcissima Lunell (R. blanda X R. woodsii) *Rose.* S. Janesville RR yard, N1 (*Greene & Koeppen, s. d.,* WIS). (Det.: Walter H. Lewis, 1960).

*R. eglanteria L. *Sweetbriar.* Escape, H1 O3.

R. Xrudiuscula Greene (R. arkansana X R. carolina) *Rose.* Roadside, N3 (*Wickham,* 1947, WIS). (Det.: Walter H. Lewis, 1959).

Rubus abactus Bailey (R. pensilvanicus) *Bramble, high-bush blackberry.* Sandy soil, A1 (*Hanson,* 1930, WIS).

R. allegheniensis Porter. *Common bramble.* Woods, K2; common.

R. alumnus Bailey (R. orarius *sensu* Gleas. & Cronq.) *Blackberry.* Open sandy river-bottom, Avon 21 (*Boebel & Laube,* 1964, WIS).

R. bellobatus Bailey (R. pensilvanicus *sensu* Gleas. & Cronq.) *Yankee blackberry.* Fencerows, woods, C2 L2 S9; frequent.

R. frondosus Bigel. (R. pensilvanicus *sensu* Gleas. & Cronq.) *Blackberry.* Wooded pasture, Newark 36 (*Fuller & MacArthur,* 1957, MIL).

R. frustratus Bailey. *Dewberry.* Railroad, Beloit (*Anthoney,* 1932, WIS).

R. hispidus L. *Swamp dewberry.* Sandy woods, T6.

R. ithacanus Bailey. *Dewberry.* Open sandy riverbottom, Avon 21 (*Boebel & Laube,* 1964, WIS).

R. occidentalis L. *Black raspberry.* Woods, fencerows, K2 L1 N1 P2 P3 P7 R1; common.

R. pergratus Blanchard (R. pensilvanicus) *Blackberry.* Woods, T7 (*Fell,* 1957, WIS).

R. rosa Bailey (R. orarius *sensu* Gleas. & Cronq.) *Raspberry.* Open woods, R1.

R. steelei Bailey (R. enslenii *sensu* Gleas. & Cronq.) *Blackberry.* Woods, L1.

R. stipulatus Bailey (R. setosus *sensu* Gleas. & Cronq.) *Bristly blackberry.* Wet woods, Avon 23 S (*Fell,* 1957, MIL).

R. strigosus Michx. (R. ideaus ssp. s.) *Red raspberry.* Sandstone, J1.

*Sorbaria sorbifolia (L.) A. Br. *False spiraea.* Janesville (*Skavlem,* 1890, WIS).

*Sorbus aucuparia L. *Mountain ash, rowan.* Woods, H1 K1.

Spiraea alba Du Roi. *Meadowsweet.* Wet ground, very common.

S. tomentosa L. *Steeple bush, hardhack.* Sandstone ledge, J2.

CAESALPINIACEAE (Caesalpinia Family)

Cassia fasciculata Michx. *Partridge pea.* Beloit (*Lapham, s. d.,* WIS).

C. hebecarpa Fern. (C. marilandica of Fassett, 1939) *Wild senna.* Lowland, Avon 18 N (*Fell,* 1957, WIS).

Gleditsia triacanthos L. *Honey locust.* Rock and Sugar Rivers, T3 T5; spreading from cult. along roads.

Gymnocladus dioica (L.) K. Koch. *Kentucky coffee-tree.* Riverbank, R1.

FABACEAE (Bean Family)

Amorpha canescens Pursh. *Lead plant.* Dry to mesic prairies, very common.

A. fruticosa L. var. angustifolia Pursh. *Indigo bush.* Riverbanks, Rock River, C2 H4 R1.

Amphicarpa bracteata (L.) Fern. *Hog peanut.* Woods, H1 H2 I3 J1 O1 Q1 R1 S8. Var. bracteata: O4 T7; common. Var. comosa (L.) Fern.: Avon 34 (*Fell,* 1957, WIS).

Apios americana Medic. *Groundnut.* Woods, O4.

Astragalus canadensis L. *Milk vetch.* Railroad, P3.

Baptisia leucantha T. & G. *White wild indigo.* Mesic prairies, D5 G2 L4 N1 P4 S1 T3.

B. leucophaea Nutt. var. leucophaea. *Cream wild indigo.* Dry to mesic prairies, woods, D5 G2 H1 I1 I2 N1 R2 S4 T3; common.

*Coronilla varia L. *Crown vetch.* Roadside, Avon 24 NE (*Fell,* 1957, WIS). Often planted for erosion control.

Desmodium canadense (L.) DC. *Showy tick trefoil.* Prairies, E5 J4 K4 L2 N1 P3 P5 P6; common.

D. cuspidatum (Muhl.) Loud. *Bracted tick trefoil.* Woods, R1 (*Fassett,* 1934, WIS).

D. dillenii Darl. *Tick trefoil.* Railroad, R1 (*Fassett,* 1934, WIS).

D. glutinosum (Muhl.) Wood (D. acuminatum) *Pointed tick trefoil.* Low woods, K2 S8 T3, Rock 34 NE; common.

D. illinoense Gray. *Illinois tick trefoil.* Prairies, B2 H1 K4 L2 N1 P4 T4.

Lathyrus ochroleucus Hook. *Wild pea.* Pastured woods, A1 O3; infrequent.

L. palustris L. *Vetchling, marsh pea.* Low woods, wet meadows, E5 J4 L4 S1 T8. Var. palustris: A5 T6. Var. myrtifolius (Muhl.) Gray: Avon 23.

L. venosus Muhl. var. intonsus Butters & St. John. *Veiny wild pea.* Prairies, H1 K4 L2 N1 R1.

Lespedeza capitata Michx., *sensu lato. Bush clover.* Prairies, fields, open woods, very common.

L. leptostachya Engelm. *Prairie bush clover.* Dry prairie, M2 (*Tans 184,* 1969, WIS). This species, last collected in Wisconsin by Davis in 1880, has been presumed extinct in the state.

Lupinus perennis L. var. occidentalis S. Wats. *Wild lupine.* Sand prairie, M1; sandy woods, S4.

*Medicago lupulina L. *Black medick.* Weed of dry gravelly ground, very common.

*M. sativa L. *Alfalfa.* Fields, roadsides, railroads, I1 N1 P5 P6 R1; common.

*Melilotus alba Desr. *White sweet clover.* Weed, very common.

*M. officinalis (L.) Desr. *Yellow sweet clover.* Weed, very common.

Petalostemum candidum (Willd.) Michx. *White prairie clover.* Prairies, I2 L2 M1; sandy woods, S4.

P. purpureum (Vent.) Rydb. *Prairie clover.* Prairies, B2 C1 D5 E4 E5 G1 G2 H1 I1 I2 L2 M1 M2 N1 R2 S1 T2.

*Robinia pseudo-acacia L. *Black locust.* Open woods, fencerows, C2 M5 N2 P3 P5 Q1 T7; common. Planted and escaped.

Tephrosia virginiana (L.) Pers. var. holosericea (Nutt.) T. & G. *Goat's rue.* Dry sandy prairies, I1 I2 M1.

*Trifolium campestre Schreb. (T. procumbens) *Low hop clover.* Disturbed ground, R1.

*T. hybridum L. *Alsike clover.* Roadsides, fields, O1 S1 P6; common.

*T. pratense L., *sensu lato. Red clover.* Roadsides, fields, railroads, very common. Much cult. and escaped.

*T. repens L. *White clover.* Lawns, fields, pastures, roadsides, very common.

*T. resupinatum L. *Persian clover.* Fassett, 1939.

Vicia americana Muhl. *American vetch, tare.* Railroads, woods, E5 K4 M8 N1 P3 P6 R1 T3; common.

*V. angustifolia Reich. *Vetch.* Railroads, N1 P5; frequent.

V. caroliniana Walt. *Wood vetch.* Woods, R1 T1; infrequent.

*V. cracca L. var. tenuifolia (Roth) G. Beck. *Tufted vetch.* Railroad, P3.
*V. villosa Roth. *Hairy vetch.* Railroad, A5; roadside, Spring Valley 31; frequent.

OXALIDACEAE (Wood Sorrel Family)

Oxalis dillenii Jacq. ssp. dillenii (O. stricta, misapplied) *Common wood sorrel.* Ubiquitous weed.
O. stricta L. (O. europaea) *Tall wood sorrel.* Ubiquitous weed.
O. violacea L. *Violet wood sorrel.* Dry prairies, C1 G1 G2 H1 I1 I2 M2 M3 R2 T4.

GERANIACEAE (Geranium Family)

Geranium carolinianum L. *Carolina cranesbill.* Sandy field, T5 (*Fell,* 1957, WIS).
G. maculatum L. *Wild geranium, spotted cranesbill.* Woods, F1 H2 I3 J1 K2 O1 O4 P2 P7 Q1 R1 S4 S8 T1.
*G. pusillum L. *Small geranium.* Janesville (*Skavlem, s. d.,* MIL).

LINACEAE (Flax Family)

Linum sulcatum Riddell. *Yellow flax.* Dry prairies, B2 C1 D5 H1 J1 M1 M2 R2 T4; common.
*L. usitatissimum L. *Common flax.* Janesville (*Skavlem,* 1889, WIS).

RUTACEAE (Rue Family)

Ptelea trifoliata L. *Hop tree.* Low woods, T3; sandstone, T2.
Zanthoxylum americanum Mill. *Prickly ash.* Open woods, K2 O3 O4 Q5 R1 T1 T3 T4 T5 T7; common.

SIMAROUBACEAE (Quassia Family)

*Ailanthus altissima (Mill.) Swingle. *Tree-of-heaven.* Spreading from cult., T3.

POLYGALACEAE (Milkwort Family)

Polygala cruciata L. *Cross milkwort.* Edgerton (*Kumlien, s. d.,* MIL).
P. incarnata L. *Pink milkwort.* Dry gravelly slope, H1.
P. polygama Walt. var. obtusata Chodat. *Purple milkwort.* Dry prairie, R2 (! Peet).
P. sanguinea L. *Field milkwort.* Low prairie, Rock 29 S.
P. senega L. *Seneca snakeroot.* Railroads, E2 H1 M8 P3 P5.
P. verticillata L. *Whorled milkwort.* Dry prairies, H1 J1.

EUPHORBIACEAE (Spurge Family)

Acalypha rhomboidea Raf. *Copperleaf, three-seeded mercury.* Dry woods, H1 S4; marshy ground, Q2 S3 S6 S7 T3 T5; common.
Chamaesyce glyptosperma (Engelm.) Small (Euphorbia g.) *Ridge-seeded spurge.* Dry sandy soil, I1 I2; infrequent.
C. maculata (L.) Small (Euphorbia m., E. supina) *Eyebane.* Sandy roadsides, fields, J1 S4, Beloit 35 E; frequent.
C. nutans (Lag.) Small (Euphorbia preslii) *Wartweed.* Roadside, Newark 35; field margin, Avon 18; railroad, Rock N.
C. vermiculata (Raf.) House (Euphorbia v.) *Hairy spurge.* Moist roadside, Avon 25 (*Fell,* 1957, WIS).
Euphorbia commutata Engelm. *Tinted spurge.* Wooded hillside, R1 (*Wadmond s. n.,* 1937, WIS). Known in Wisconsin only from Big Hill Park (*cf.* Fassett, 1933).
E. corollata L. var. corollata. *Flowering spurge.* Prairies, dry open woods, roadsides, railroads, very common.
*E. cyparissias L. *Cypress spruge.* Low pasture, M7; railroad, Union 16.
*E. esula L. Leafy spurge. Roadside, Carver's Rock, Bradford 27.
*E. marginata Pursh. *Snow-on-the-mountain.* Roadside escape, Beloit 2 (*Fell,* 1957, WIS).
E. obtusata Pursh. *Blunt-leaved spurge.* Riverbottom, T5 (*Fell 57-404,* 1957, WIS). Only Wisconsin collection.

CALLITRICHACEAE (Water Starwort Family)

Callitriche palustris L. (C. verna) *Water starwort.* Spring, O2.

ANACARDIACEAE (Cashew Family)

Rhus aromatica Ait. *Fragrant sumac.* Sandy slope, T2. Wisconsin's rarest native shrub.
R. glabra L. *Smooth sumac.* Open woods, prairies, roadsides, very common.
R. radicans L. (Toxicodendron r.). Var. radicans. *Climbing poison ivy.* Bottomland woods, T3 T5. Var. rydbergii (Small) Rehd. *Low poison ivy.* Woods, B2 H2 H4 L1 O2 Q1 R1 S8 T1 T7; common.
R. typhina L. *Staghorn sumac.* Roadsides, D7, Johnstown 11.
R. vernix L. *Poison sumac.* Sphagnum bog, E1, locally abundant.

AQUIFOLIACEAE (Holly Family)

Ilex verticillata (L.) Gray. *Black alder.* Sphagnum bog, E1; woods, T6, Avon 36.

CELASTRACEAE (Staff-tree Family)

Celastrus scandens L. *Bittersweet.* Dry woods, roadsides, cliffs, railroads, B2 H2 J1 K2 R1 S9 T1 T2 T7; common.
*Euonymus alatus (Thunb.) Sieb. *Winged wahoo.* Spreading from cult., H5.
E. atropurpureus Jacq. *Burning bush, wahoo.* Low woods, T3 T5; dry roadside, Newark 31 C; limestone, C3.
*E. europaeus L. *Spindle tree.* Spreading from cult., corner of Bayliss and Glen, Beloit.

STAPHYLEACEAE (Bladdernut Family)

Staphylea trifolia L. *Bladdernut.* Woods, C3 H4 O3 R1 T3; ravine opposite old sewage plant, Janesville.

ACERACEAE (Maple Family)

Acer negundo L. *Box elder.* Woods, fencerows, streambanks, abandoned fields. Both vars. negundo and interius (Britt.) Sarg. are very common.
A. saccharinum L. *Silver maple.* Low woods, M5 P3 P5 T3 T5.
A. saccharum Marsh. var. saccharum. *Sugar maple.* Mesic woods, O4 R1.

HIPPOCASTANACEAE (Horse-chestnut Family)

*Aesculus glabra Willd. *Ohio buckeye.* Spreading from cult., Lima 25 E; Yahara River near Fulton (*Curtis, Greene, & Sauer,* 1954, WIS).

BALSAMINACEAE (Touch-me-not Family)

Impatiens capensis Meerb. (I. biflora) *Orange jewelweed, spotted touch-me-not.* Marshes, low woods, very common.
I. pallida Nutt. *Yellow jewelweed, pale touch-me-not.* Low woods, T3 T5; ditch, H2.

RHAMNACEAE (Buckthorn Family)

Ceanothus americanus L. *New Jersey tea.* Prairies, dry open woods, B2 C3 E5 H1 K4 L1 L2 N1 P6 S4.
C. herbaceus Raf. (C. ovatus) *Redroot.* Railroad, Beloit (*Collector unknown,* 1876, WIS).
Rhamnus alnifolia L'Her. *Alder buckthorn.* Sphagnum bog, E1.
*R. cathartica L. *Common buckthorn.* Open woods, fencerows, very common.
*R. frangula L. *Glossy buckthorn.* Riverbank, H4; sphagnum bog, E1.
R. lanceolata Pursh. *Lance-leaved buckthorn.* Mesic wooded cliff, H4, several shrubs (! Musselman).

VITACEAE (Grape Family)

Parthenocissus quinquefolia (L.) Planch. *Virginia creeper, woodbine.* Woods, O3.
P. inserta (Kerner) K. Fritsch (P. vitacea) *Thicket* or *Virginia creeper.* Woods, thickets, embankments, very common.
Vitis aestivalis Michx. var. argentifolia (Munson) Fern. *Summer grape.* Dry woods, K2 T5.

V. riparia Michx. (V. vulpina) *Frost grape, riverbank grape.* Woods, fencerows, very common.

TILIACEAE (Linden Family)

Tilia americana L. *Basswood.* Woods, C2 H1 H2 H3 H4 J1 M3 O1 O3 O4 Q1 R1 T3 T5.

MALVACEAE (Mallow Family)

*Abutilon theophrasti Medic. *Velvetleaf.* Lots, cult. fields, very common.
*Althaea rosea L. *Hollyhock.* Roadside, 04; persisting near dwellings.
Hibiscus moscheutos L. ssp. palustris (L.) Clausen. *Rose mallow.* Janesville, (*Skavlem s. n.,* 1889, WIS). Only Wisconsin collection.
*H. trionum L. *Flower-of-an-hour.* Disturbed open ground, O2; infrequent.
*Malva moschata L. *Musk mallow.* Janesville (*Skavlem,* 1889, WIS).
*M. neglecta Wallr. *Cheeses, common mallow.* Lawns, fields, roadsides, especially cult. ground, very common.
*M. rotundifolia L. *Round-leaved mallow.* Field, N3 (*Wickham,* 1947, WIS).
Napaea dioica L. *Glade mallow.* Low woods, wet prairies, marshes, L2 L4 N2 O2 O3 Q2 T3 T5.

HYPERICACEAE (St. John's-wort Family)

Hypericum gentianoides (L.) BSP. *Orange grass.* Sandy slope, J2.
H. majus (Gray) Britt. *St. John's-wort.* Wet margins, E1 S6.
*H. perforatum L. *Common St. John's-wort.* Roadsides, railroads, fields, P3 R2, Spring Valley 21 W; frequent.
H. punctatum Lam. *Spotted St. John's-wort.* Woods, H1.
H. pyramidatum Ait. (H. ascyron) *Great St. John's-wort.* Marsh, O2; low open woods, T3.
H. sphaerocarpum Michx. *Round-fruited St. John's-wort.* Bottomland, T3 (*Fell,* 1957, WIS). In Wisconsin only on wet prairies along the Rock and Sugar Rivers in Rock and Green Counties.
Triadenum fraseri (Spach) G1. (Hypericum virginicum f.) *Marsh St. John's-wort.* Sphagnum bog, E1; marsh, S2.

CISTACEAE (Rockrose Family)

Helianthemum bicknellii Fern. *Bicknell's frostweed.* Dry sand, I1.
H. canadense (L.) Michx. *Common rockrose.* Dry sand, I2 J1 J2 J3 L1 O2 R2 S4 T1.
Lechea intermedia Leggett. *Pinweed.* Dry gravelly prairie, M2.
L. stricta Leggett. *Bushy pinweed.* Dry sand, I1 I2 J1 J3 M2 S4; common.
L. tenuifolia Michx. *Slender-leaved pinweed.* Sand, Newark 31 (*Fell,* 1957, WIS).

VIOLACEAE (Violet Family)

Viola affinis LeConte. *Violet.* Roadside, O7 (*Fell,* 1957, WIS).
V. cucullata Ait. *Marsh blue violet.* Damp ground, H2 L4 Q1 R1 T5; common.
V. missouriensis Greene. *Missouri violet.* Wooded ground, riverbottom, Avon 35 (*Fassett,* 1935, WIS).
V. nephrophylla Greene. *Northern bog violet.* Railroad, P3 (*Fell,* 1957, WIS); frequent.
*V. odorata L. *Sweet violet.* Woods, Milton (*Hadow,* 1958, WIS).
V. pallens (Bank) Brain. *Smooth white violet.* Sphagnum bog, E1.
V. papilionacea Pursh. *Meadow violet.* Streamside, P7.
V. pedata L. var. lineariloba DC. *Birdfoot* or *pansy violet.* Dry prairies, dry open woods, B2 C1 D5 G1 G2 H1 I1 J1 J3 L1 R2 S4 T1 T2 T6.
V. pedatifida G. Don. *Prairie violet.* Dry prairies, D5 H1 N1.
V. pedatifida X V. nephrophylla. *Violet.* Low prairie, P3 (*Fell,* 1957, WIS).
V. pubescens Ait. Var. pubescens. *Downy yellow violet.* Woods, K2 Q1 R1 S8. Var. eriocarpa (Schw.) Russ. *Smooth yellow violet.* Woods, H2 O4 R1.

V. rugulosa Greene. *Violet.* Open woods, Avon 31 (*Fell,* 1957, WIS).
V. sagittata Ait. *Arrow-leaved violet.* Dry woods, J1 T6; low prairie, J4.
V. septentrionalis Greene. *Violet.* Woods, H2.
V. sororia Willd. *Hairy wood violet.* Wet meadows, low woods, L2 P1 P2 P7 T1 T5; common.
V. sororia X V. missouriensis. *Violet.* Sugar River bottoms, Avon (*Fassett & Meyer,* 1928, WIS).
V. sororia X V. nephrophylla. *Violet.* Low ground, Avon 1 *(Fell,* 1957, WIS).
V. striata Ait. *Cream violet.* Mesic woods, O1 (*Olds s. n.,* 1895, WIS). Only Wisconsin collection.

THYMELAEACEAE (Mezereum Family)

Dirca palustris L. *Leatherwood.* Woods, H4, locally abundant.

ELAEAGNACEAE (Oleaster Family)

*Shepherdia canadensis (L.) Nutt. *Buffaloberry.* Spreading from cult., L1.

LYTHRACEAE (Loosestrife Family)

Decodon verticillatus (L.) Ell. var. laevigatus T. & G. *Water Willow.* Floating bog mat, E1, locally abundant.
Lythrum dacotanum Nieuwl. (L. alatum) *Loosestrife.* Low prairies, marshes, A1 B1 D3 E1 E4 F2 J4 L2 L3 O2 R1 S1 S6 S7.

ONAGRACEAE (Evening Primrose Family)

Circaea alpina L. *Enchanter's nightshade.* Beloit (*Swezey, s. d.,* WIS).
C. quadrisulcata (Maxim.) Franch. & Sav. var. canadensis (L.) Hara. *Enchanter's nightshade.* Woods, H2 J1 K2; frequent.
Epilobium angustifolium L. *Fireweed.* Railroad embankment, A5.
E. coloratum Biehler. *Cinnamon willow herb.* Wet areas, A1 D1 D3 E1 L3 O2 O3 R1 S1 S2 S3 S7 T3 T5.
E. leptophyllum Raf. *Bog willow herb.* Sedge meadows, wet prairies, E1 S2 S6.
Gaura biennis L. *Gaura.* Dry prairie, G2; streambank, T3; railroad, O5.
Ludwigia palustris (L.) Ell. var. americana (DC.) Fern. & Grisc. *Water purslane.* Ugent, 1962.
L. polycarpa Short & Peter. *False loosestrife.* Wet ditch, S6.
Oenothera biennis L. *Common evening primrose.* Prairies, B2 S1; railroads, roadsides; common.
O. parviflora L. *Evening primrose.* Railroads, P1 P3 P4 P5; common.
O. perennis L. *Sundrops.* Low prairies, J4 O4; frequent.
O. rhombipetala Nutt. *Sand evening primrose.* Open sandy woods, S4.
*O. serrulata Nutt. *Toothed evening primrose.* Railroad ballast, M1; gravel pit, M7. Native in westernmost Wisconsin, rarely adventive eastward.
O. strigosa (Rydb.) Mack. & Bush. *Evening primrose.* Sand prairie, T3.

HALORAGIDACEAE (Water Milfoil Family)

Myriophyllum exalbescens Fern. (M. spicatum) *Water milfoil.* Lakes, B1 D4 D7, locally abundant.
Proserpinaca palustris L. *Mermaid weed.* "Bog," Avon I2 (*Fell,* 1957, WIS).

HIPPURIDACEAE (Mare's Tail Family)

Hippuris vulgaris L. *Mare's tail.* Janesville (*Skavlem,* 1889, WIS).

ARALIACEAE (Ginseng Family)

Aralia nudicaulis L. *Wild sarsaparilla.* Dry woods, I3 J1 L1 O1 S8; common.
A. racemosa L. *Spikenard.* Rich woods, H2 H4 I3 K2 O1 R1.

UMBELLIFERAE (Parsley Family)

Angelica atropurpurea L. *Alexanders, angelica.* Wet prairies, marshes, sloughs. Var. atropurpurea is rare and var. occidentalis Fassett very common.

Berula erecta (Huds.) Cov. *Water parsnip.* Springs, H3 O2.
*Carum carvi L. *Caraway.* Railroad, P6; roadsides, Bradford 21 S, Beloit 18 N.
Chaerophyllum procumbens (L.) Crantz. *Wild chervil.* Low woods, T3 T5, locally abundant. Only Wisconsin stations.
Cicuta bulbifera L. *Water hemlock.* Ditch, sphagnum bog, E1; infrequent.
C. maculata L. *Water hemlock.* Low prairies, L2 L4 P3 P5 T3 T5.
Cryptotaenia canadensis (L.) DC. *Honewort.* Woods, H2 O1 Q1 R1 S8 T3 T5.
*Daucus carota L. *Queen Anne's lace, wild carrot.* Ubiquitous weed.
*Eryngium leavenworthii T. & G. *Eryngo.* Janesville (*Skavlem,* 1915, MIL).
E. yuccifolium Michx. *Rattlesnake master.* Mesic prairies, J4 K4 L2 N1 P3 P5 S1.
Heracleum lanatum Michx. (H. maximum) *Cow parsnip.* Marshes, low woods, M8 N2 P6 Q2 R1.
Osmorhiza claytonii (Michx.) Clarke. *Sweet cicely.* Woods, very common.
O. longistylis (Torr.) DC. *Anise-root.* Woods, very common.
Oxypolis rigidior (L.) C. & R. *Cowbane.* Low prairies, fens, E5 J4 O2 P3 S1.
*Pastinaca sativa L. *Parsnip.* Fields, roadsides, very common.
Polytaenia nuttallii DC. *Prairie parsley.* Dry prairies, G2 M8 P6, Milton 32 S.
Sanicula gregaria Bickn. *Black snakeroot.* Woods, H2 K2 P7 T3 T5.
S. marilandica L. *Black snakeroot.* Woods, very common.
S. trifoliata Bickn. *Black snakeroot.* Woods, I3 Q1 R1.
Sium suave Walt. *Water parsnip.* Marshes, low woods, O5 T3; infrequent.
Taenidia integerrima (L.) Drude. *Yellow pimpernel.* Prairies, P3 P4 P6; roadside, Newark 15 S.
Thaspium trifoliatum (L.) Gray var. flavum Blake. *Meadow parsnip.* Prairies, L2 P3 P5, Turtle 31.
Zizia aptera (Gray) Fern. *Heart-leaved Alexanders.* Prairies, G2 I1 L1 L2 N1 P5 Q5; common.
Z. aurea (L.) Koch. *Golden Alexanders.* Prairies, roadsides, very common.

CORNACEAE (Dogwood Family)

Cornus alternifolia L. f. *Pagoda* or *alternate-leaved dogwood.* Woods, C3 H4 I3 O1 O4 R1.
C. amomum Mill. ssp. obliqua (Raf.) Wilson (C. obliqua) *Silky dogwood.* Low woods, moist thickets, E1 H3 R1 R2 S6 T1 T3 T5; common.
C. foemina L. ssp. racemosa (Lam.) Wilson (C. racemosa) *Gray dogwood.* Woods, fencerows, roadsides, B2 D5 H1 J1 K2 L1 P3 Q6 R1 S1 S4 S6 S8 T7.
C. alba L. ssp. stolonifera (Michx.) Wang. (C. stolonifera) *Red osier.* Wet prairies, marshes, low woods, streambanks, very common.

ERICACEAE (Health Family)

Andromeda glaucophylla Link. *Bog rosemary.* Sphagnum bog, E1.
Chamaedaphne calyculata (L.) Moench (Cassandra c.) *Leatherleaf.* Floating bog mat, A1, locally abundant.
Chimaphila umbellata (L.) Bart. var. cisatlantica Blake. *Prince's pine.* Dry sandy woods, S4.
Gaylussacia baccata (Wang.) K. Koch. *Huckleberry.* Dry sandy woods, often on outcrops, J1 J2 J3 L1 M4 T1 T6.
Monotropa uniflora L. *Indian pipe, pinesap.* Woods, H1 S4 T7.
Pyrola elliptica Nutt. *Shinleaf.* Woods, F1 L1 S4 T7.
Vaccinium macrocarpon Ait. *Cranberry.* Floating bog mat, Milton 17.
V. myrtilloides Michx. *Velvet-leaf blueberry.* Sandy woods, J3 L1 M4 T6.
V. oxycoccos L. *Small cranberry.* Sphagnum bog, E1.

PRIMULACEAE (Primrose Family)

*Anagallis arvensis L. *Scarlet pimpernel.* Janesville (*Skavlem,* 1890, WIS).
Androsace occidentalis Pursh. *Rock jasmine.* Sandy road, D1 (*Thomson,* 1945, WIS).
Dodecatheon meadia L. *Shooting star.* Dry gravelly to low alkaline prairies, open woods, rather common.

Lysimachia ciliata L. (Steironema c.) *Fringed loosestrife.* Marshes, sloughs, streamsides, E4 J4 O2 P3 R1 R2 S1 T3 T5; common.
L. lanceolata Walt. (Steironema l.) *Lance-leaved loosestrife.* Dry woods, L1; prairie, J4.
*L. nummularia L. *Moneywort.* Low woods, C2 M5 M6 S5 T3.
L. quadriflora Sims (Steironema q.) *Marsh loosestrife.* Mesic prairies, fens, E5 L2 O2 S1 S6.
L. terrestris (L.) BSP. *Swamp candles.* Low woods, T3 T5.
L. thyrsiflora L. (Naumbergia t.) *Tufted loosestrife.* Marshes, bogs, shrub-carrs, A1 B1 E1 O2 S5; frequent.
Trientalis borealis Raf. *Starflower.* Sphagnum hummocks, E1.

OLEACEAE (Olive Family)

Fraxinus americana L. *White ash.* Woods, H4 R1.
F. nigra Marsh. *Black ash.* Riversides, C2 H4 M5 T3; frequent.
F. pennsylvanica Marsh. Mesic to wet woods, B1 B2 H1 H2 J1 K1 O1 O3 O4 P2 Q1 R1 T1 T3 T5. Var. pennsylvanica. *Red ash.* Common. Var. subintegerrima (Vahl.) Fern. (F. p. lanceolata) *Green ash.* Common.
*Syringa vulgaris L. *Lilac.* Spreading from cult., T7; persisting near dwellings.

GENTIANACEAE (Gentian Family)

Gentiana andrewsii Griseb. *Bottle gentian.* Sedge meadows, low prairies, streamsides, low woods, D3 E2 E3 F2 H3 L2 L3 M3 O2 S1 S2 S3 S6 S7 T3 T5.
G. crinita Froel. (Gentianopsis c.) *Fringed gentian.* Fens, L2 O2 S6.
G. Xcurtisii Pringle (G. puberulenta X G. alba) *Curtis' gentian.* Holotype: mesic prairie, N1 (*Mason 1470,* 1951, WIS).
G. alba Muhl. (G. flavida) *White gentian.* Ditch, Janesville 13.
G. procera Holm (Gentianopsis p.) *Small fringed gentian.* Low prairie, O2.
G. puberulenta Pringle (G. puberula) *Prairie gentian.* Gravel-hill prairies, C1 D5 G2 M2 R2; dry sandy woods, S4.
G. quinquefolia L. ssp. occidentalis (Gray) Gillett (Gentianella q.) *Staff gentian.* Dry to mesic prairies, E5 H1 L2.
Menyanthes trifoliata L. var. minor Raf. *Buckbean.* Sphagnum bogs, A1 E1.

APOCYNACEAE (Dogbane Family)

Apocynum androsaemifolium L. *Dogbane.* Woods, S8; railroads, N1 P3 P5; frequent.
A. cannabinum L. *Indian hemp.* Railroads, dry woods, E5 H1 N1 P3 P5 P6.
A. sibiricum Jacq. *Indian hemp.* Bottomland, T5 (*Fell,* 1957, WIS).

ASCLEPIADACEAE (Milkweed Family)

Asclepias amplexicaulis Sm. *Sand milkweed.* Railroad ballast, N1 (*Green,* 1947, WIS); sand, 12 (! Peet).
A. exaltata L. *Poke milkweed.* Rich woods, S8.
A. hirtella (Pennell) Woods. (Acerates h.) *Tall green milkweed.* Prairies, H1 S1.
A. incarnata L. *Swamp milkweed.* Open wet places, A1 B1 C2 D8 E1 E4 J4 L2 P3 R1 S1 T8.
A. lanuginosa Nutt. (Acerates l.) *Woolly milkweed.* Dry prairies, I2 R2.
A. ovalifolia Dcne. *Milkweed.* Janesville (*Skavlem,* 1889, WIS).
A. purpurascens L. *Purple milkweed.* Wet-mesic prairie, S1 (! Peet).
A. sullivantii Engelm. *Prairie milkweed.* Railroad, P3 (*Curtis, Greene, & Sauer,* 1954, WIS).
A. syriaca L. *Common milkweed.* Mesic to low prairies, fields, roadsides, railroads, very common.
A. tuberosa L. ssp. interior Woods. *Butterfly weed.* Sandy prairie, M1; railroad, P4.
A. verticillata L. *Milkweed.* Dry prairies, weed of fields and roadsides, B2 C1 D5 E4 G1 G2 H1 I1 I2 J1 M2 O1 O3 P3 P5.
A. viridiflora Raf. (Acerates v.) *Short green milkweed.* Prairies, G2 N1 P4.

CONVOLVULACEAE (Morning-glory Family)

*Convolvulus arvensis L. *Field bindweed.* Fields, roadsides, railroads, very common.

C. sepium L., *sensu lato. Wild morning-glory, hedge bindweed.* Distrubed open ground, D5 N1 P3 P5 P6 R2; common.

C. spithamaeus L. *Dwarf bindweed.* Roadside, O1.

Cuscuta glomerata Choisy. *Rope dodder.* Marshes, O2 O5.

C. gronovii Willd. *Common dodder, strangleweed.* Wet ground, E3 H3 M3 O2 Q2 R1 S3; common.

*Ipomoea hederacea (L.) Jacq. *Morning-glory.* Railroad, P3 (*Fell,* 1957, WIS).

POLEMONIACEAE (Phlox Family)

*Gilia rubra (L.) Heller. *Standing cypress.* Dry sandy roadside, S4 (*Musselman 1610,* 1967, ULJ). Second Wisconsin collection.

Phlox bifida Beck. ssp. bifida. *Cleft phlox.* Sandy woods, S4 (*Fell & Fell 46253,* 1946, WIS). Often cult., but this collection, one of two from Wisconsin, probably native.

P. divaricata L. var. laphamii Wood. *Blue* or *woodland phlox.* Low woods, O4 Q1 R1 T3 T5.

*P. paniculata L. *Perennial phlox.* Gully edge, H1.

P. pilosa L. var. fulgida Wherry. *Prairie phlox.* Prairies, J4 L2 N1 P3 P4 P5 P6 R2 S1; common.

Polemonium reptans L. *Jacob's ladder, Greek valerian.* Low prairies, J4 L2; moist woods, H2 H3 O4 Q1 R1.

HYDROPHYLLACEAE (Waterleaf Family)

Ellisia nyctelea L. *Wild tomato.* Low open woods, M5 Q1 T3 T5, locally abundant.

Hydrophyllum appendiculatum Michx. *Great waterleaf.* Red oak-maple woods, H4 R1.

H. virginianum L. *Virginia waterleaf.* Woods, H2 J1 K2 K3 O1 O3 O4 Q1 R1; common.

BORAGINACEAE (Borage Family)

*Cynoglossum officinale L. *Hound's tongue.* Pastures, A1 E1 O2; frequent.

Hackelia virginiana (L.) Johnst. *Beggar's lice.* Mixed oak woods, D7 (*Mori,* 1965, WIS); infrequent.

*Lappula myosotis Moench (L. echinata) *Stickseed.* Railroad, N1 (*Green,* 1947, WIS).

*Lithospermum arvense L. *Corn gromwell.* Janesville (*Skavlem,* 1912, MIL).

L. canescens (Michx.) Lehm. *Hoary puccoon.* Dry to mesic prairies, I1 I2 J4 L2 M1 M2 N1 P3 P5 P7.

L. caroliniense (Walt.) MacM. (L. croceum) *Hairy puccoon.* Sandy prairie, M1; infrequent.

L. incisum Lehm. *Fringed puccoon.* Dry prairies, B2 C1 H1 J1 M1 R2 T7.

L. latifolium Michx. *Gromwell, broad-leaved puccoon.* Rich woods, Q1.

Mertensia virginica (L.) Pers. *Virginia bluebell, lungwort.* Island in Sugar River (*Wadmond,* 1934, WIS).

*Myosotis scorpioides L. *Forget-me-not.* Spring, O2, locally abundant.

Onosmodium molle Michx. var. hispidissimum (Mack.) Cronq. *False gromwell, marbleseed.* Beloit (*Skavlem,* 1889, WIS).

VERBENACEAE (Vervain Family)

Lippia lanceolata Michx. (Phyla l.) *Fog fruit, lippia.* Streambanks, C2 O5; marsh margins, O4 T3.

*Verbena bracteata Lag. & Rodr. *Creeping vervain.* Dry roadside, Avon 7; infrequent.

V. hastata L. *Blue vervain.* Low open ground, O3 S1 S7 T8; common.

V. Xrydbergii Moldenke (V. hastata X V. stricta) *Rydberg's vervain.* Low weedy field, Q2.

V. simplex Lehm. (V. angustifolia) *Narrow-leaved vervain.* Harmony (*Skavlem,* 1890, WIS).

V. stricta Vent. *Hoary vervain.* Dry prairies, B2 I1 M2 N2 R2; fields, pastures, E4 M5 Q2 Q5; common.

V. urticifolia L. *White vervain.* Dry open woods, T7. Var. urticifolia: woods, O1; thickets, O3 Q2; roadsides, O7, Newark 19. Var. leiocarpa Perry & Fern.: roadside, La Prairie 31 (*Wickham,* 1947, WIS).

LABIATAE (Mint Family)

Agastache scrophulariaefolia (Willd.) Ktze. *Giant hyssop.* Roadside 8 miles W of Beloit (*Anthoney,* 1936, WIS).

*Ballota nigra L. var. nigra (B. n. ruderalis) *Black horehound.* Roadside, Avon 10 (*Fell 57-791,* 1957, WIS). Two of the three Wisconsin collections are from Rock County.

Blephilia ciliata (L.) Benth. *Woodmint.* Dry woods, H1 H2 O1 O4; prairies, G2 L2 S1.

Dracocephalum parviflorum Nutt. *Dragonhead.* Beloit (*Collector unknown, s. d.,* WIS).

*Glechoma hederacea L. var. micrantha Moricand (G. h. parviflora) *Creeping Charlie, ground ivy.* Damp soil, H2 M5 O1 O4 Q1 Q2, locally abundant.

Hedeoma hispidum Pursh. *Mock pennyroyal.* Railroads, sandy fields, B2 J1 M1; frequent.

H. pulegioides (L.) Pers. *American pennyroyal.* Woods, E1 (*Fell,* 1957, WIS).

*Hyssopus officinalis L. *Hyssop.* Beloit (*Skavlem,* 1890, WIS).

Isanthus brachiatus (L.) BSP. *False pennyroyal.* Prairie, Newark 31 (*Fell,* 1957, WIS).

*Lamium maculatum L. *Dead nettle.* Janesville (*Skavlem,* 1889, WIS).

*Leonurus cardiaca L. *Motherwort.* Woods, thickets, pastures, embankments, H2 J1 J4 M5 O3 P4 Q1 Q2 Q6; common.

Lycopus americanus Muhl. *Water horehound.* Wet places, very common.

L. Xsherardii Steele (L. uniflorus X L. virginicus) *Sherard's water horehound.* Low woods, T5 (*Fell,* 1957, WIS).

L. uniflorus Michx. *Bugleweed.* Wet ground, E1 O2 S7 T3.

Mentha arvensis L. *Wild mint.* Var. lanata Piper: marsh, O2; frequent. Var. villosa Benth.: springs, marshes, sphagnum bog, E1 F2 M3 O3; common.

*M. cardiaca Gerarde. *Small-leaved mint.* Koeppen, 1957.

*M. gentilis L. *Spotted mint.* Wet field, S7.

*M. piperita L. *Peppermint.* Marsh, O3; streambottom, Bradford 34.

Monarda fistulosa L. *Wild bergamot, horsemint.* Prairies, pastures, dry open woods, railroads. Var. fistulosa is infrequent and var. mollis (L.) Benth. very common.

*Nepeta cataria L. *Catnip.* Yards, pastures, fencerows, embankments, open woods, very common.

Physostegia formosior Lunell. *False dragonhead.* Streambottoms, M3 M5 O5 T3 T5.

*Prunella vulgaris L. var. lanceolata (Bart.) Fern. *Heal-all.* Yards, pastures, roadsides, open woods, very common.

Pycnanthemum virginianum (L.) Durand & Jackson. *Mountain mint.* Mesic prairies, E4 E5 J4 L2 O2 P3 P5 P6 S1 S6 S7 T3.

*Salvia reflexa Hornem. *Rocky Mountain sage.* Barnyard, Spring Valley 29 (*Fell,* 1957, WIS).

Scutellaria epilobiifolia A. Hamilton (S. galericulata) *Marsh skullcap.* Marshes, A1 A3 E1 E4.

S. lateriflora L. *Mad-dog skullcap.* Wet ground, E1 L2 O2 P1 T3 T5 T8.

S. ovata Hill ssp. versicolor (Nutt.) Epl. *Heart-leaved skullcap.* Mesic woods, Q1.

S. parvula Michx. *Small skullcap.* Var. parvula: edge of Turtle Creek, La Prairie 34 (*Green,* 1947, WIS). Var. leonardii (Epl.) Fern.: dry prairies, G2 J1 M2 R2 S4.

Stachys tenuifolia Willd. var. hispida (Pursh) Fern. (S. hispida) *Hedge nettle.* Low ground, S3 (*Fell,* 1957, WIS); frequent.

S. palustris L., *sensu lato. Woundwort.* Open wet places, E1 J4 L2 O2 P3 P4 P5 P6 S1 T1; common.

Teucrium canadense L. *Wood sage, germander.* Low ground. Var. occidentale (Gray) McClintock & Epl.: O3 Q2 T3 T5, Milton 11. Var. virginicum (L.) Eat.: O1 T5.

SOLANACEAE (Nightshade Family)

*Lycium halimifolium Mill. *Matrimony vine.* Beloit (*Olds,* 1893, WIS).

Physalis heterophylla Nees. *Clammy ground cherry.* Prairies, B2 D5 J4 K4 N1 P3 P4 T3; common.

P. longifolia Nutt. var. subglabrata (Mack. & Bush) Steyerm. (P. virginiana s.) *Tall ground cherry.* Mesic prairies, A5 O3 P3 P5, Avon 34, Plymouth 4.

P. virginiana Mill. var. virginiana. *Lance-leaved ground cherry.* Dry to mesic prairies, fields, D5 M2 N1 N3 R2, Avon 25; common.

Solanum americanum Mill. (S. nigrum auth.) *Black nightshade.* Railroads, P3 P6; field, Avon 34; lawn, Q1; common.

*S. carolinense L. *Horse nettle.* Fields, H1 T3.

*S. dulcamara L. *Bittersweet nightshade.* Weed, A1 E1 H1 H2 L3 O4 P3 P5 Q1 Q2; common.

*S. rostratum Dunal. *Buffalo bur.* Roadsides, Center 20, La Prairie 19.

SCROPHULARIACEAE (Figwort Family)

Agalinis aspera (Dougl.) Britt. (Gerardia a.) *Rough gerardia.* Dry prairie, T2.

A. tenuifolia (Vahl.) Raf., *sensu lato* (Gerardia t.) *Slender gerardia.* Marshes, fens, D1 E1 L2 S6 T1, Avon 29 W, Rock 9.

Aureolaria grandiflora (Benth.) Pennell var. pulchra (Pennell) Fern. (Gerardia g.) *False foxglove.* Dry oak woods, B2 H1 L1; along Bass Creek, Rock 27.

A. pedicularia (L.) Raf. var. ambigens Fern. (Gerardia p.) *Clammy false foxglove.* Dry sandy woods, L1 S4.

Besseya bullii (Eat.) Rydb. (Wulfenia b.) *Kitten tails.* Dry prairies, J1 M1 M2; open woods, J3 T1; common.

Castilleja coccinea (L.) Spreng. *Scarlet painted cup, Indian paintbrush.* Low meadows, O2 S1 T3.

C. sessiliflora Pursh. *Yellow painted cup.* Gravel-hill and high-lime prairies, C1 I1 T2.

*Chaenorrhinum minus (L.) Lange. *Dwarf snapdragon.* Railroad ballast, Spring Valley 21 (*Nee,* 1969, WIS).

Chelone glabra L., *sensu lato. Turtlehead.* Wet prairies, streambanks, marsh margins, D3 E1 O2 R1 S1 S2 S3 S7 T8; common.

Collinsia verna Nutt. *Blue-eyed Mary.* Wooded hillside, Janesville (*Hagen s. n.,* 1931, WIS). Only Wisconsin collection.

Gratiola neglecta Torr. *Clammy hedge hyssop.* Drainage ditch, S6.

Linaria canadensis (L.) Dum. *Blue toadflax.* Sandy slope, I2.

*L. vulgaris Hill. *Butter-and-eggs.* Fields, roadsides, railroads, O3 O5 P4 Q2; common.

Lindernia dubia (L.) Pennell. *False pimpernel.* Muddy shores, O5 S5; marsh, O2.

Mimulus glabratus HBK. var. fremontii (Benth.) Grant. *Yellow monkey flower.* Spring, O2, locally abundant.

M. ringens L. *Monkey flower.* Wet ground, very common.

Pedicularis canadensis L. *Wood betony.* Dry gravelly prairie, G2; dry woods, L1; frequent.

P. lanceolata Michx. *Lousewort.* Low grassy ground, often marly, B1 D3 E1 E2 E3 E4 J4 O2 O4 S1 S2 S3 S6 S7 T6 T8.

Penstemon bradburii Pursh (P. grandiflorus) *Large-flowered beard tongue.* Dry prairies, R2, Janesville 22; roadsides along Hwy. K, Newark 30, 31.

P. digitalis Nutt. *Foxglove beard tongue.* Streamside, Avon 6 W (*Fell,* 1957, WIS).

P. hirsutus (L.) Willd. *Hairy beard tongue.* Rock (*Skavlem,* 1890, WIS).

Scrophularia lanceolata Pursh. *Early figwort.* Open woods, railroads, roadsides, I2 K4 N1 O1 P3; frequent.

S. marilandica L. *Late figwort.* Open woods, L1 O1 P3 P4.

*Verbascum blattaria L. *Moth mullein.* Railroad, Union 22.

*V. thapsus L. *Mullein, flannel plant.* Dry fields, open woods, roadsides, railroads, very common.

*Veronica arvensis L. *Corn speedwell.* Field, T3, locally common; infrequent.

V. comosa Richter (V. catenata, V. connata) *Water speedwell.* Drainage ditch, E7.
V. peregrina L. *Purslane speedwell.* Weed, especially of low cult. ground. Var. peregrina: G1 T3; common. Var. xalapensis (HBK.) St. John & Warren: Fulton 18, Magnolia 8; common.
*V. serpyllifolia L. ssp. serpyllifolia. *Thyme-leaved speedwell.* Woods, O4 (*Fell,* 1957, WIS).
Veronicastrum virginicum (L.) Farw. (Veronica v.) *Culver's root.* Low prairies, E5 J4 L2 L4 P3 P4 P5 S1 T3.

BIGNONIACEAE (Trumpet Creeper Family)

*Catalpa speciosa Warder. *Northern catalpa.* Escape, H5 Q6 T3.

LENTIBULARIACEAE (Bladderwort Family)

Utricularia intermedia Hayne. *Flat-leaved bladderwort.* Sphagnum bog, A1 (*Hanson,* 1930, WIS).
U. vulgaris L. *Great bladderwort.* Ditch, L2; pond, E7.

ACANTHACEAE (Acanthus Family)

Ruellia humilis Nutt. *Wild petunia.* Millrace at Beloit, a little N of Turtle Creek and the state line (*Wadmond,* 1931, WIS).

PHRYMACEAE (Lopseed Family)

Phryma leptostachya L. *Lopseed.* Dry woods, very common.

PLANTAGINACEAE (Plantain Family)

Plantago aristata Michx. *Bracted plantian.* Dry prairies, J1 M2 T3.
*P. lanceolata L. *English plantain, ribgrass.* Lawns, fields, roadsides, I2 Q7; frequent.
*P. major L. *Common plantain.* Fields, lawns, roadsides, very common.
P. patagonica Jacq. (P. purshii) *Woolly plantain.* Dry sand, K2 T3; gravel pit, M7.
*P. indica L. *Whorled plantain.* Woods border, Janesville (*Woodworth,* 1954, UWM).
P. rugelii Dcne. *Red-stemmed plantain.* Weed, especially of damp ground, very common.

RUBIACEAE (Madder Family)

Cephalanthus occidentalis L. *Buttonbush.* Riversides, M3 T3 T5; frequent.
Galium aparine L. *Cleavers.* Mesic woods and riverbottoms (the plants native), weedy in various habitats (the plants possibly introduced from Eurasia); very common.
G. asprellum Michx. *Rough bedstraw.* Woods, O2; low prairie, S2.
G. boreale L. ssp. septentrionalis (Roem. & Schult.) Hara. *Northern bedstraw.* Low to mesic prairies, E5 J4 L2 L4 N1 P3 P6 S1 T3; common.
G. concinnum T. & G. *Pretty bedstraw.* Woods, H2 O4 P7 Q1 R1 S8 T3 T5; common.
G. labradoricum (Wieg.) Wieg. *Bog bedstraw.* Somewhat alkaline sphagnum bog, E1.
G. obtusum Bigel. var. ramosum Gleas. *Wild madder.* Low prairie, S1, marshes, A4 E1.
G. tinctorium L. *Stiff bedstraw.* Sphagnum bog, E1; infrequent.
G. trifidum L. *Small bedstraw.* Sedge meadow, T8; low woods, T5.
G. triflorum Michx. *Fragrant bedstraw.* Low to mesic woods, H2 K2 O4 P2 P7 R1.
Houstonia caerulea L. *Bluets.* Low prairie, J4; marsh margin, A1.
Mitchella repens L. *Partridgeberry.* Dry woods, H1.

CAPRIFOLIACEAE (Honeysuckle Family)

Diervilla lonicera Mill. *Bush honeysuekle.* N-facing sandstone slopes, H4 J1 J3 K2 M4.
Linnaea borealis L. var. americana (Forbes) Rehd. *Twinflower.* Dry woods, Beloit (*Scheuber,* 1884, WIS).
*Lonicera Xbella Zabel (L. morrowi X L. tatarica) *Honeysuckle.* Low woods, R1.
L. dioica L. var. dioica. *Wild honeysuckle.* Woods, P7 T3.
*L. morrowii Gray. *Morrow's honeysuckle.* Open woods, P6 P7 Q1.
L. oblongifolia (Goldie) Hook. *Swamp fly honeysuekle.* "Bogs," Beloit (*Scheuber,* 1884, WIS).

L. prolifera (Kirch.) Rehd. *Grape honeysuckle.* Woods, B2 R1 S8; shrub-carr, O2.
*L. tatarica L. *Tartarian honeysuckle.* Open woods. H1 M5 P6; frequent.
L. villosa (Michx.) R. & S. *Waterberry.* Sphagnum bog, E1.
Sambucus canadensis L. *Common elderberry, blue-berried elder.* Woods, shrub-carrs, marsh margins, streamsides, roadsides, very common.
S. pubens Michx. *Red-berried elder.* Kettle-pond margin, Union 23 (*Fassett & Meyer,* 1928, WIS).
Symphoricarpos albus (L.) Blake var. albus. *Snowberry.* Railroads, E2 E4 L2 L4 M2 R1, Fulton 15.
S. occidentalis Hook. *Wolfberry.* Dry prairie, M2; railroad, Rock 30.
Triosteum perfoliatum L. *Horse gentian.* Oak woods. Var. perfoliatum: R1 (*Anthoney,* 1932, WIS). Var. aurantiacum (Bickn.) Wieg.: O1 T3 T7; Frequent. Var. illinoense Wieg.: Afton (*Davis,* 1913, WIS).
Viburnum dentatum L. var. lucidum Ait. *Southern arrow-wood.* Open mesic woods, C3 H4 O1.
*V. lantana L. *Wayfaring tree.* Escape, sandstone cliff, H4.
V. lentago L. *Nannyberry.* Woods, fencerows, railroads, E2 E4 H1 H3 K2 O2 O4 O5 Q1 T5 T6.
V. opulus L. *Highbush cranberry.* *Ssp. opulus: roadside, H5; open woods, Janesville 23. Ssp. trilobum (Marsh.) Clausen: moist woods, H2; sphagnum bog, E1.
V. rafinesquianum Schult. *Downy arrow-wood.* Dry woods, C3 H2. Var. rafinesquianum: H1 Q1 T7. Var. affine (Bush) House: O1 R1.

ADOXACEAE (Moschatel Family)

Adoxa moschatellina L. *Moschatel.* Rich woods, O3 (*Musselman 3487,* 1970, ULJ, UWM). First Wisconsin collection outside of the Driftless Area.

VALERIANACEAE (Valerian Family)

Valeriana edulis Nutt. var. ciliata (T. & G.) Cronq. (V. ciliata) *Valerian.* Mesic prairies, G2 L2.
*V. officinalis L. *"Garden heliotrope."* Janesville (*Skavlem,* 1890, WIS).

DIPSACACEAE (Teasel Family)

*Dipsacus laciniatus L. *Teasel.* Leeson Park dump, Turtle 30 SW.

CUCURBITACEAE (Gourd Family)

Echinocystis lobata (Michx.) T. & G. *Wild* or *prickly cucumber.* Wet ground, especially streamsides, C1 D1 E3 H1 M3 N2 O2 O3 O4 O5 Q1 R1 T1 T3 T5.

CAMPANULACEAE (Harebell Family)

Campanula americana L. *Tall bellflower.* Moist woods, C2 M3 N2 O1 O2 Q1 T3 T5; common.
C. aparinoides Pursh var. aparinoides. *Marsh bellflower.* Marshes, E1 E4 S2; low prairie, S1.
*C. rapunculoides L. *European bellflower.* Roadside, O2.
C. rotundifolia L. var. intercedens (Witasek) Farw. *Harebell, bluebell.* Dry prairies, B2 D5 G2 M2 R2.
Specularia perfoliata (L.) A. DC. (Triodanis p.) *Venus' looking-glass.* Weed, dry sandy field, T3.

LOBELIACEAE (Lobelia Family)

Lobelia cardinalis L. *Cardinal flower.* Low open woods, T3.
*L. inflata L. *Indian tobacco.* Disturbed dry woods, H1.
L. kalmii L. *Kalm's lobelia.* Fens, E1 L2 S6.
L. siphilitica L. *Great lobelia.* Low ground, thickets, L3 O1 O2 O5 S1 S2 S3 S7 T3 T5 T7 T8.
L. spicata Lam., *sensu lato. Pale-spiked lobelia.* Prairies, G2 H1 J4 L2 N1 R2 S1 T3; dry woods, O4 E1; common.

COMPOSITAE (Composite Family)

Achillea millefolium L. ssp. lanulosa (Nutt.) Piper. *Yarrow.* Ubiquitous throughout.

Ambrosia artemisiifolia L. *Common ragweed.* Ubiquitous throughout.

A. psilostachya DC. *Western ragweed.* Sand prairies, T2 T4 T7.

A. trifida L. *Great ragweed.* Riverbottoms, T3 T5 T7; weed of deep soils, very common.

Anaphalis margaritacea (L.) Benth. & Hook. *Pearly everlasting.* Janesville (*Skavlem,* 1889, WIS).

Antennaria fallax Greene (A. plantaginifolia ambigens) *Giant pussytoes.* Sandy prairie, M1; open woods, Magnolia 15.

A. neglecta Greene. *Pussytoes, ladies' tobacco.* Prairies, H5 L2; common.

A. parlinii Fern. (A. plantaginifolia arnoglossa) *Smooth pussytoes.* Grazed mesic woods, O4; infrequent.

A. plantaginifolia (L.) Richards. *Plantain-leaved pussytoes.* Dry open ground, H1 J1 L1 L2 M1 M2 O2 T6, Turtle 2 N; common.

*Anthemis cotula L. *Dog fennel, chamomile.* Field, N3 (*Wickham,* 1947, WIS); roadsides, railroads, especially cult. ground; common.

*Arctium minus Schk. *Burdock.* Roadsides, fields, especially in rich soil, P3 P5 P6; common.

*Artemisia absinthium L. *Absinthium.* Disturbed ground, R1 (*Fell,* 1957, WIS).

*A. biennis Willd. *Biennial wormwood.* Weedy roadside, Fulton 12 (*Aronson & Pierce,* 1967, WIS).

A. caudata Michx. (A. campestris c.) *Wild* or *beach wormwood.* Sandy and gravelly prairies, dry open woods, I2 I3 L1 M1 S4.

A. dracunculoides Pursh (A. dracunculus, A. glauca) *Dragon sagewort.* Janesville (*Skavlem,* 1889, WIS).

A. ludoviciana Nutt. ssp. ludoviciana. *White sage.* Prairies, H1 K4 R1; railroad ballast, L2.

A. serrata Nutt. *Sawtooth sagebrush.* Damp peaty soil, H3.

Aster azureus Lindl. *Rough-leaved* or *sky-blue aster.* Dry to mesic prairies, D5 H1 I1 K4 L2 L4 N1 T2 T4; common.

A. cordifolius L. *Blue woodland aster.* Moist woods, H2 M4 O3.

A. drummondii Lindl. *Drummond's aster.* Roadside, Harmony 27 (*Wickham,* 1947, WIS).

A. ericoides L. *Heather* or *wreath aster.* Prairies, D5 E5 G2 H1 K4 L2 N1.

A. laevis L. *Smooth aster.* Prairies, E5 H1 J4 K4 L4 M4 N1.

A. lateriflorus (L.) Britt. *White woodland aster.* Weed, thickets or open ground, S6 T3 T5; common.

A. linearifolius L. *Narrow-* or *stiff-leaved aster.* Prairies, woods, C1 I2 I3 S4.

A. macrophyllus L. *Large-leaved aster.* Creek ravine, O1.

A. novae-angliae L. *New England aster.* Wet ground, A1 D2 D3 E1 E2 E5 F2 J4 L2 L3 M2 O2 O3 O5 Q2 S6 S7 T3.

A. oblongifolius Nutt. var. angustatus Shinners. *Aromatic aster.* Dry calcareous prairies, G1 G2 J1 T7.

A. ontarionis Wieg. (A. pantotrichus) *Ontario aster.* Roadside ditch, Avon 23 (*Fell,* 1957, WIS).

A. pilosus Willd., *sensu lato. Hairy aster.* Prairies, fields, roadsides, railroads, D5 D7 L3 M2 O2 O3 O4 O5 Q2 S1 S2 T6.

A. ptarmicoides (Nees) T. & G. (Solidago p.) *Stiff* or *white upland aster.* Dry calcareous prairies, C1 D5 G2 R2 T2 T4.

A. puniceus L. Forma puniceus. *Swamp aster.* Wet ground, S3 (*Fell,* 1957, WIS). Forma lucidulus (Gray) Fern. *Shining aster.* Marshes, E1 O2; streambank, P1.

A. sagittifolius Willd. *Arrow-leaved aster.* Prairies, open woods, B2 L2 T7; common.

A. sericeus Vent. *Silky aster.* Dry sandy or gravelly prairies, B2 C1 D5 G2 M1 M2 N1 T4.

A. shortii Lindl. *Short's aster.* Dry railroad embankment, R1.

A. simplex Willd. *Tall white aster.* Var. interior (Wieg.) Cronq.: wet ground, Avon 12 (*Fell,* 1957, WIS); common. Var. ramosissimus (T. & G.) Cronq. (A. paniculatus): wet ground, Avon 8 (*Fell,* 1957, WIS).

A. umbellatus Mill. *Flat-topped aster.* Low prairies, S3 T6.

Bidens cernua L., *sensu lato. Nodding bur marigold.* Shores, sloughs, marshes, wet meadows, A1 A2 E3 H3 L2 L3 N2 O2 O3 O4 O5 S2 S3 S7 T3 T5.

B. comosa (Gray) Wieg. *Leafy-bracted beggar-ticks.* Marshes, A3 O6.

B. connata Muhl. var. petiolata (Nutt.) Farw. *Swamp tickseed* or *stick-tight.* Swampy pond margin, Milton 6 (*Iltis & Janecek,* 1956, WIS).

B. coronata (L.) Britt. var. tenuiloba (Gray) Sherff. *Tickseed sunflower.* Disturbed wet ground, E1 O2 O5 S1 T8.

B. frondosa L. *Common bur marigold.* Var. frondosa: wet ground, Q2 S5. Var. pallida Wieg.: shore marsh, A3.

B. vulgata Greene. *Tall stick-tight.* Wet ground. Var. vulgata: N3 (*Wickham,* 1947, WIS). Var. puberula (Wieg.) Greene: P3 T3 T5.

Cacalia atriplicifolia L. *Pale Indian plantain.* Mesic prairie, N1 (*Green,* 1947, WIS).

C. suaveolens L. *Sweet Indian plantain.* Low prairies, P4 S2; shrub-carr, T8.

C. tuberosa Nutt. *Indian plantain.* Wet-mesic prairies, L2 S1.

*Carduus nutans L. *Nodding thistle.* Turtle 11 (! Peet).

*Centaurea maculosa Lam. *Star thistle.* Sandy or gravelly roadsides and fields, M5; railroad ballast, Beloit 12 S; infrequent.

*Chrysanthemum leucanthemum L. *Ox-eye daisy.* Fields, roadsides, railroads, I1 I2 N1 P4; frequent.

*Cichorium intybus L. *Chicory.* Roadsides, streets, railroads, L3 O5; frequent.

Cirsium altissimum (L.) Spreng. *Tall* or *wood thistle.* Open mesic woods, H2.

*C. arvense (L.) Scop. *Canada thistle.* Roadsides, pastures, cult. fields, very common.

C. discolor (Muhl.) Spreng. *Prairie thistle.* Prairies, E5 G2 J4 K4 L2 L4 N1 P3 S1.

*C. flodmanii (Rydb.) Arthur. *Flodman's thistle.* CMStPP RR, Bradford (*Wadmond,* 1934, WIS).

C. hillii (Canby) Fern. (C. pumilum ssp. h.) *Small prairie thistle.* Gravelly calcareous prairies, D5 R2.

C. muticum Michx. *Swamp thistle.* Wet prairies, L4 O2 S1 S2.

*C. vulgare (Savi) Ten. *Bull thistle.* Prairies, pastures, open woods, roadsides, L1 O3 O7 S1; common.

Coreopsis palmata Nutt. *Tickseed, prairie coreopsis.* Dry to mesic prairies, very common.

Echinacea pallida Nutt. *Purple coneflower.* Dry to mesic prairies, G2 N1 P4 R2.

Erechtites hieracifolia (L.) Raf. *Fireweed, pilewort.* Woods 6 miles W of Beloit (*Anthoney,* 1934, WIS).

Erigeron annuus (L.) Pers. *Annual fleabane.* Open woods, T7; fields; common.

E. canadensis L. (Conyza c.) *Horseweed.* Dry fields, roadsides, railroads, very common.

E. philadelphicus L. *Daisy* or *Philadelphia fleabane.* Weed, especially of rich soil, L2 O1 O4; common.

E. pulchellus Michx. *Robin's plantain.* Shaded pasture, O4; open oak woods, R1; common.

E. strigosus Muhl., *sensu lato. Daisy fleabane.* Very common weed of dry open ground.

Eupatorium altissimum L. *Tall boneset.* Prairies, N1 Q2.

E. maculatum L. *Spotted Joe-Pye weed.* Marshes, shrub-carrs, wet open woods, E1 E2 F2 O2 O3 O4 O5 Q2 S1 T8; common.

E. perfoliatum L. *Common boneset.* Marshes, wet prairies, E1 E2 E4 F2 O2 O3 O4 O5 O7 S1 S2 S3 T8.

E. purpureum L. *Purple Joe-Pye weed.* Woods, Q1 S9, Turtle 12.

E. rugosum Houtt. var. tomentellum (Robins.) Blake. *White snakeroot.* Moist woods, weedy in thickets, H2 O3 Q2 T7; common.

*Galinsoga ciliata (Raf.) Blake. *Peruvian daisy.* Open shaded limestone, H2; street, M5; gardens, hedges; common.

Gnaphalium obtusifolium L. var. obtusifolium. *Sweet cudweed.* Dry fields, prairies, open woods, B2 C1 D5 H1 I1 I2 J2 L1 M2 M5 R1 R2 S4 T7.

*Grindelia squarrosa (Pursh) Dunal. *Tarweed.* Roadside, Rock 24.

Helenium autumnale L., *sensu lato. Sneezeweed.* Wet prairies, sedge meadows, shrub-carrs, ditches, D3 E5 M3 O2 O3 O5 O7 Q2 S1 S7 T8.

*Helianthus annuus L. *Garden sunflower.* Quarry, O6; infrequent.

H. giganteus L. *Tall sunflower.* Wet soil, L3, Turtle 30; common.

H. grosseserratus Martens. *Sawtooth sunflower.* Wet prairies, marshes, streambanks, E5 H1 J4 N1 T8; common.

H. laetiflorus Pers. var. rigidus (Cass.) Fern. *Prairie* or *showy sunflower.* Mesic prairies, E5 J4 N1 P3 S1; frequent.

H. occidentalis Riddell. *Western sunflower.* Prairies, D5 L2 M1 M2 N1.

H. strumosus L. *Harsh sunflower.* Roadside, Spring Valley 22 (*Fell,* 1957, WIS); open woods; common.

H. tuberosus L. *Jerusalem artichoke.* Damp ground, L2 Q2 T5; frequent.

Heliopsis helianthoides (L.) Sweet ssp. occidentalis Fisher. *Ox-eye.* Prairies, A4 B2 E4 H2 J4 L2 L4 N1.

Heterotheca villosa (Pursh) Shinners var. villosa (Chrysopsis v. v., C. ballardii) *Golden aster.* Dry prairie, P5.

Hieracium kalmii L. (H. canadense *sensu* floras) *Kalm's hawkweed.* Dry woods, H1 T6.

H. longipilum Torr. *Long-bearded* or *prairie hawkweed.* Dry prairies, M2 R2.

H. scabriusculum Schwein. var. scabriusculum (H. umbellatum s.) *Narrow-leaved hawkweed.* Wet-mesic prairie, S1.

H. scabrum Michx. var. scabrum. *Rough hawkweed.* Open woods, T7 (*Fell,* 1957, WIS).

Krigia biflora (Walt.) Blake. *Dwarf dandelion.* Dry prairies. Ssp. biflora: R1 R2. Ssp. glandulifera (Fern.) Iltis: Beloit (*McIlheny, s. d.,* WIS).

Kuhnia eupatorioides L. var. corymbulosa T. & G. *False boneset.* Dry prairies, B2 H1 L2 S2 T2 T4.

Lactuca biennis (Moench) Fern. *Wood lettuce.* Low woods, T5.

L. canadensis L. *White lettuce.* Var. canadensis: along Bass Creek 3 miles E of Hanover. Var. latifolia Ktze.: prairies, N1 O2; frequent.

L. floridana (L.) Gaertn. *Blue-flowered lettuce.* Open mesic woods, Q1.

L. ludoviciana (Nutt.) DC. *Prairie lettuce.* Mesic prairie, N1.

*L. serriola L. (L. scariola) *Prickley lettuce.* Roadsides, railroads, lots, disturbed prairies and woods, very common.

*Lapsana communis L. *Nipplewort.* Urban weed, M5, Turtle 31.

Liatris aspera Michx. *Rough blazing star.* Dry prairies, E5 G2 H1 L1 M2 N1 S4.

L. cylindracea Michx. *Cylindrical blazing star.* Dry prairies, E5 G2 T2.

L. Xgladewitzii (Farw.) Shinners (L. aspera X L. cylindracea) *Gladewitz' blazing star.* Dry prairie, G2.

L. pycnostachya Michx. *Prairie gayfeather.* Low prairies, E5 L2 S1 T3.

*Matricaria discoidea DC. (M. matricarioides) *Pineapple weed.* Fields, railroads, especially streets and roadsides, very common.

Microseris cuspidata (Pursh) Schultz-Bip. (Agoseris c.) *Prairie dandelion.* Beloit (*Swezey, s. d.,* WIS). Probably extinct.

Prenanthes alba L. *Lion's foot.* Woods, fencerows, L1 O4 Q1 T7; common.

P. aspera Michx. *Rough rattlesnake-root.* Dry prairie, G2.

P. racemosa Michx. *Glaucous rattlesnake-root.* Mesic prairies, L2 S1.

*Ratibida columnifera (Nutt.) Woot. & Standl. *Prairie coneflower.* Gravel pit, M7. Native in northwestern Wisconsin.

R. pinnata (Vent.) Barnh. *Yellow coneflower.* Dry to wet-mesic prairies, B2 D5 E4 E5 G2 H1 J4 L2 N1 P3 P5 P6 S1 T3.

Rudbeckia hirta L. (Incl. R. serotina) *Black-eyed Susan.* Prairies, roadsides, open woods, very common.
R. laciniata L. *Wild goldenglow.* Low woods, T3 T5.
R. subtomentosa Pursh. *Sweet black-eyed Susan.* Low prairie, Avon 36 (*Fell,* 1957, WIS).
R. triloba L. *Brown-eyed Susan.* Wet open ground, O2, Newark 8.
Senecio aureus L. *Golden ragwort.* Low prairies, E2 L2.
S. pauperculus Michx. *Northern ragwort.* Moist open ground, L2 O4 R1 S1.
S. plattensis Nutt. *Prairie groundsel.* Dry prairies, roadsides, I1 M1 M7 M8 R1 R2.
Silphium integrifolium Michx. *Rosinweed.* Mesic prairies, E5 G2 K4 L2 N1 P3 S1.
S. laciniatum L. *Compass plant.* Mesic prairies, D5 L2 L4 N1 P3 P5 P6 S1.
S. perfoliatum L. *Cup plant.* Wet open woods, streamsides, prairies, H3 L2 N1 O2 O3 O5 Q2 T3 T5 T8.
S. terebinthinaceum Jacq. *Prairie dock.* Mesic prairies, E1 N1 O5 P3 S1.
Solidago altissima L. *Tall goldenrod.* Mesic prairie, N1 (*Green,* 1947, WIS); fields, roadsides, fencerows, very common.
S. canadensis L. *Canada goldenrod.* Var. canadensis: low meadow, S3; infrequent. Var. gilvocanescens Rybd.: open woods, fields, streamsides, roadsides, railroads; very common.
S. flexicaulis L. *Zigzag goldenrod.* Woods, C3 H2 O3 O4 R1.
S. gigantea Ait. *Late goldenrod.* Moist fields, fens, marshes, streambanks. Var. gigantea: O3 S3 P3 T5; common. Var. serotina (Ktze.) Cronq.: O2 O3 S6, Avon 29; common.
S. graminifolia (L.) Salisb., *sensu lato. Grass-leaved goldenrod.* Dry sandy to mesic fields and prairies, I2 L2 L4 P3 T7.
S. gymnospermoides (Greene) Fern. *Goldenrod.* Dry open woods, I3 S4.
S. juncea Ait. *Early goldenrod.* Moist open ground, O1 O2.
S. missouriensis Nutt. var. missouriensis. *Missouri goldenrod.* Prairies, dry woods, E5 H1 I3 L1 L4 M3 N1 O2 O3 Q2 R2.
S. nemoralis Ait. *Field goldenrod.* Prairies, dry woods. Var. nemoralis: H1 J3 L1 M2 N1; common. Var. decemflora (DC.) Fern.: I2 S4; frequent.
S. patula Muhl. *Rough-leaved* or *swamp goldenrod.* Springy fen, O2.
S. riddellii Frank. *Fen goldenrod.* Fens, E1 L2 S5; low prairies, E4 E5 O2 S6.
S. rigida L. *Stiff goldenrod.* Prairies, rarely a weed in pastures, D5 E5 G2 H1 L2 M3 M4 N1 O2 O7 R2 S1.
S. speciosa Nutt. *Showy goldenrod.* Var. speciosa: woods, M4; prairie, N1. Var. rigidiuscula Rydb.: prairies, D5 N1 T6.
S. uliginosa Nutt. var. uliginosa. *Bog goldenrod.* Low prairies, L2 O2.
S. ulmifolia Muhl. *Elm-leaved goldenrod.* Mesic woods, H2 O1 T7.
*Sonchus asper (L.) Hill. *Spiny sow thistle.* Roadside, H2.
*S. oleraceus L. *Sow thistle.* Disturbed low fields, E2 O2.
*S. uliginosus Bieb. *Smooth sow thistle.* Damp fields, pasture, roadsides, F2 O5 P3 P4; common.
*Tanacetum vulgare L. *Tansy.* Roadside, E2.
*Taraxacum officinale Wiggers, *sensu lato. Common dandelion.* Ubiquitous weed.
*Tragopogon dubius Scop. (T. major) *Goat's beard.* Very common weed.
*T. porrifolius L. *Salsify, oyster plant.* Plymouth 27 W (*Curtis & Greene,* 1957, WIS).
*T. pratensis L. *Common goat's beard.* Roadsides, streets, railroads, P3 P5; common.
Vernonia fasciculata Michx. *Ironweed.* Low prairies, O3 S2 T3; frequent.
Xanthium strumarium L., *sensu lato. Cocklebur.* Weed, especially of cult. ground, H3 M5.

EXCLUDED SPECIES

Comptonia peregrina (L.) Coult. (Myrica asplenifolia) *Sweet fern.* Probably attributed erroneously to Rock County by Bergseng (1963), but reported from Winnebago County, Ill., by Fell (1955).

Polygonum erectum L. *Erect knotweed.* Reported for Rock County by Mahony (1932), but the specimen (Janesville: *Skavlem,* 1889, WIS) has been redetermined as P. aviculare L.? (Det.: T. R. Mertens, 1966).

Aureolaria flava (L.) Farw. (Gerardia f.) *False foxglove.* Erroneously ascribed to Rock County and perhaps to Wisconsin by Salamun (1951).

STATISTICAL SYNOPSIS

The catalogue lists a total of 1,137 species. Of the 945 species collected by the authors only *Agrimonia parviflora* is a new record for Wisconsin. It has not been determined how many are new records for Rock County. The number of species known for the latter falls short of that which appeared in the *Flora of Winnebago County, Illinois* (Fell, 1955) by 74, but today nearly 100 more species are known from Winnebago County than fifteen years ago. Winnebago County lies midway across the northern boundary of Illinois immediately south of Rock County. It is notable that fully 56% of the species of vascular plants comprising Wisconsin's flora are present in Rock County. The Compositae with 47 genera and 140 species and the Gramineae with 46 genera and 100 species are the largest families. The largest genus is *Carex* with 62 species. Fifty-five genera have five or more species, and nine of these, *Aster, Polygonum, Salix, Solidago, Viola, Rubus, Panicum, Asclepias,* and *Ranunculus,* each have more than ten species. Hybrids and infraspecific taxa have not been included in the following tabulation.

	Species		Genera	Families
Major Groups of Tracheophytes	Native	Introduced		
Pteridophytes	30	0	18	6
Gymnosperms	4	1	3	3
Monocotyledons	238	33	104	18
Dicotyledons	627	204	349	94
Totals	899	238	474	121

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"What a thousand acres of *Silphium* looked like when they tickled the bellies of the buffalo is a question never again to be answered, and perhaps not even asked."

–Aldo Leopold

PTERIDOPHYTES OF BEAVER ISLAND, CHARLEVOIX COUNTY, MICHIGAN

Lorraine Calhoun Veldman and Daniel E. Wujek
Department of Biology,
Central Michigan University, Mount Pleasant

The region around the upper Great Lakes has long been known as a botanically interesting area with a varied flora. The present contribution is the result of an opportunity to study the pteridophyte flora of an area located in the northern end of Lake Michigan.

Beaver Island, the largest of the Beaver group, is located approximately 30 mi. off the northwest coast of the lower peninsula of Michigan. The island covers 58.4 square miles and has a shoreline of 41.6 mi.; it is 12 mi. long and 6 mi. wide at the widest point.

The shores vary from broad to narrow, and are variously sandy, marshy, or in one place, of bedrock. Lakes on the island are shallow, some with firm sandy shores and bottoms, as the north shore of Font Lake and Lake Genesareth. Others with boggy shores and soft bottoms, abundantly vegetated, are such as Barney's Lake and Miller's Marsh. The lakes are surrounded by open meadows, hardwood forests, or occasionally, cedar bogs. Bog conditions are found around the borders of some lakes and marshes, particularly at Egg Lake and Green's Lake with typical *Sphagnum* associates. Cedar swamps are found in areas of peaty soil. The grasslands, occupying a relatively small part of the island, are represented by pastures, meadows and stumpland (Hatt et al., 1948).

The flora of Beaver Island is similar in many respects to that of the nearby mainland; the climax forest before lumbering was primarily beech-maple (Darlington, 1940). Along the shore and in the northern portion pines are now dominant, while on the captured dunes grow abundant *Populus.* Toward the interior the well-developed stands of hardwoods are heavily dominated by *Fagus grandifolia* with abundant *Acer saccharum, Tsuga,* and *Betula. Pinus strobus* and *Quercus rubra* are less frequent in these stands. On abandoned farmland, *Juniperus communis* var. *depressa* is very abundant. *Thuja occidentalis, Picea mariana,* and *Abies balsamea* occupy cedar swamps (Kapp et al., 1969).

Billington's (1952) survey of the pteridophytes of Michigan records a total of 35 species for Charlevoix County. Since this time, investigators have made further collections from the county, including the island. Most notable among these collectors were M. Reis, Sister M. Horton, and E. G. Voss. More recently, Hagenah (1966) has reported on the distribution of the Ophioglossaceae of the county and island in his study of Michigan pteridophytes.

We report here 44 species and varieties of pteridophytes, including 8 Lycopodiaceae, 3 Selaginellaceae, 1 Isoetaceae, 8 Equisetaceae, 7 Ophioglossaceae, 3 Osmundaceae, and 14 Polypodiaceae, all of which were found

during the summers of 1969 and 1970. Our collections include all of but 3 of the species listed for Charlevoix County by Billington (1952): *Cystopteris fragilis* Bernh., *Athyrium thelypteroides* (Michx.) Desv., and *A. pycnocarpon* (Spreng.) Tidest.

Voucher specimens for the annotated check list which follows are deposited in the herbarium of Central Michigan University (CMC). We wish to thank Dr. W. H. Wagner, Jr., for checking many of the specimens and Dr. M. H. Hohn for use of the facilities at Central Michigan University's Biological Station.

CHECKLIST OF PTERIDOPHYTES OF BEAVER ISLAND CHARLEVOIX COUNTY, MICHIGAN

An asterisk before the name indicates a taxon first reported for the county. Nomenclature is that of Wherry (1961).

Lycopodiaceae

Lycopodium lucidulum Michx.
**L. annotinum* L.
L. annotinum var. *acrifolium* Fern.
L. clavatum L.
**L. obscurum* L.
L. tristachyum Pursh.
L. complanatum L.
**L. flabelliforme* (Fern.) Blanchard.

Selaginellaceae

**Selaginella apus* (L.) Spring.
S. selaginoides (L.) Link.
S. rupestris Spring.

Isoetaceae

**Isoetes muricata* Dur.

Equisetaceae

Equisetum hyemale L.
E. variegatum Schleich.
E. scirpoides Michx.
E. palustre L.
E. fluviatile L.
E. sylvaticum L.
E. arvense L.
**E. ×ferrissii* Clute

Ophioglossaceae

**Botrychium multifidum* (Gmel.) J. F. Gmel.
B. virginianum (L.) Sw.
B. matricariaefolium A. Braun.
**B. minganense* Vict.
**B. lunaria* (L.) Sw.
**B. simplex* Hitch.
**B. lanceolatum* var. *angustisegmentum* Pease & Moore.

Osmundaceae

Osmunda regalis var. *spectabilis* (Willd.) Gray.
O. claytoniana L.
O. cinnamomea L.

Polypodiaceae

Adiantum pedatum L.
Pteridium aquilinum var. *latiusculum* (Desv.) Underw.
Athyrium angustum (Willd.) Presl.
Dryopteris intermedia (Muhl.) Gray.
D. spinulosa (O. F. Muell.) Watt.
D. marginalis (L.) Gray.
D. cristata (L.) Gray.
Cystopteris bulbifera (L.) Bernh.
Matteucia pensylvanica (Willd.) Raymond.
Onoclea sensibilis L.
Thelypteris palustris var. *pubescens* (Lawson) Fern.
Phegopteris connectilis (Michx.) Watt.
Gymnocarpium dryopteris (L.) Newm.
Polypodium virginianum L.

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Nature education feature --

WILDFLOWERS IN WINTER: A PROJECT OF THE MICHIGAN BOTANICAL CLUB

Helen V. Smith
Herbarium, The University of Michigan, Ann Arbor

We are all aware of the beauty of wildflowers in full bloom in the woods, in the open fields, and along the waterways. Many of us are not aware of the amount of interest and beauty to be found in their stark remains in the winter-time also. In recent years there has been increasing use of dried plants in arrangements as well as their use in special "weed holders." There is an explosive increase in the number of people participating in outdoor recreation in winter and thus exposed to the sight of dried weeds projecting above the snow. In order to bring a new dimension of plant study and appreciation to those who come into contact with dried plants in these and other ways, the Michigan Botanical Club has undertaken the preparation of a booklet to be called "Winter Wildflowers." The object is to show the inherent beauty of this often overlooked facet of nature and to aid people to identify plant specimens in the winter condition through the presentation of photographs. As is usual in such undertakings the initial enthusiasm was great, and it was hoped that all necessary pictures could be speedily taken. This hope was in vain as it was considered important that the photographs be not only good from a technical standpoint but pleasing to the eye as well.

The photographs shown here are a selection from those considered satisfactory for our proposed booklet and show a variety of treatments. It is hoped that this will serve as an inspiration to members of the Michigan Botanical Club and their photographer friends to make every effort to get more good photographs this fall so that we can proceed with putting the booklet together this year. We are interested primarily in herbaceous species that are striking in aspect and which are easily recognized or which are particularly effective in dried arrangements. The black and white photographs should preferably be between 5 X 7 and 8 X 10 and on paper suitable for reproduction. If you don't know what you are taking a picture of, save the specimen and send it along with the photograph to Mrs. Helen V. Smith, University of Michigan Herbarium, Ann Arbor, Michigan 48104.

People who are willing to help in this project but who are not photographers could perform a great service by collecting *good* dried specimens for indoor photography. These need to be carefully handled to prevent breakage. They can be stood upright in soft drink bottles, or in grocery sacks—or put into plastic bags. We can use a few good photographs of arrangements or other uses of dried plants also; our early attempts at these were not especially satisfactory.

The following list gives the species for which we have the best photographs. It would be better to concentrate on species not on this list as we are desirous of adding variety. However, a really spectacular shot of the listed species would be welcome.

Abutilon theophrasti	Indian Mallow
Apocynum cannabinum	Common Dogbane
Arctium minus	Common Burdock
Asclepias incarnata	Swamp Milkweed
Asclepias syriaca	Common Milkweed
Cirsium sp.	Thistle
Cypripedium sp.	Lady's-slipper
Datura stramonium	Jimsonweed
Daucus carota	Queen Anne's-lace
Dioscorea villosa	Wild Yam
Lespedeza capitata	Round-headed Bush-clover
Lythrum salicaria	Spiked Loosestrife (indoor portrait; could use an outdoor shot, also)
Monarda fistulosa	Wild Bergamot
Phragmites communis	Reed (indoor portrait; need an outdoor shot also)
Physalis sp.	Ground-cherry
Scrophularia sp.	Figwort
Tragopogon sp.	Goat's-beard
Typha latifolia	Common Cat-tail
Verbena urticifolia	White Verbena

Queen Anne's-lace Kenneth Coles

Common Cat-tail

Kenneth Coles

Indian Mallow Beatrice Dunn

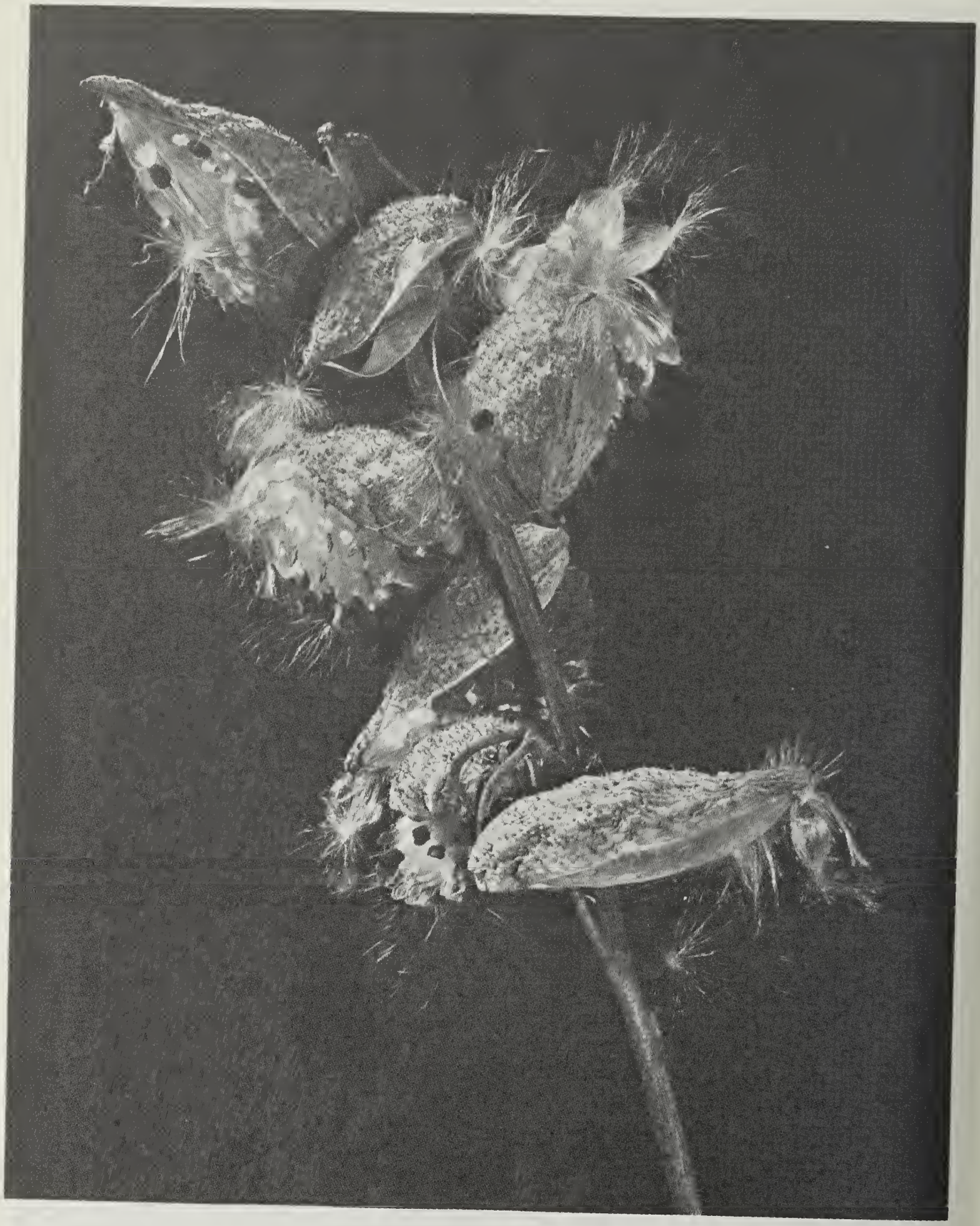
Pitcher Plant Yvonne Wilson

Burdock F. Hostman

Cat-tail Donald R. Farrar

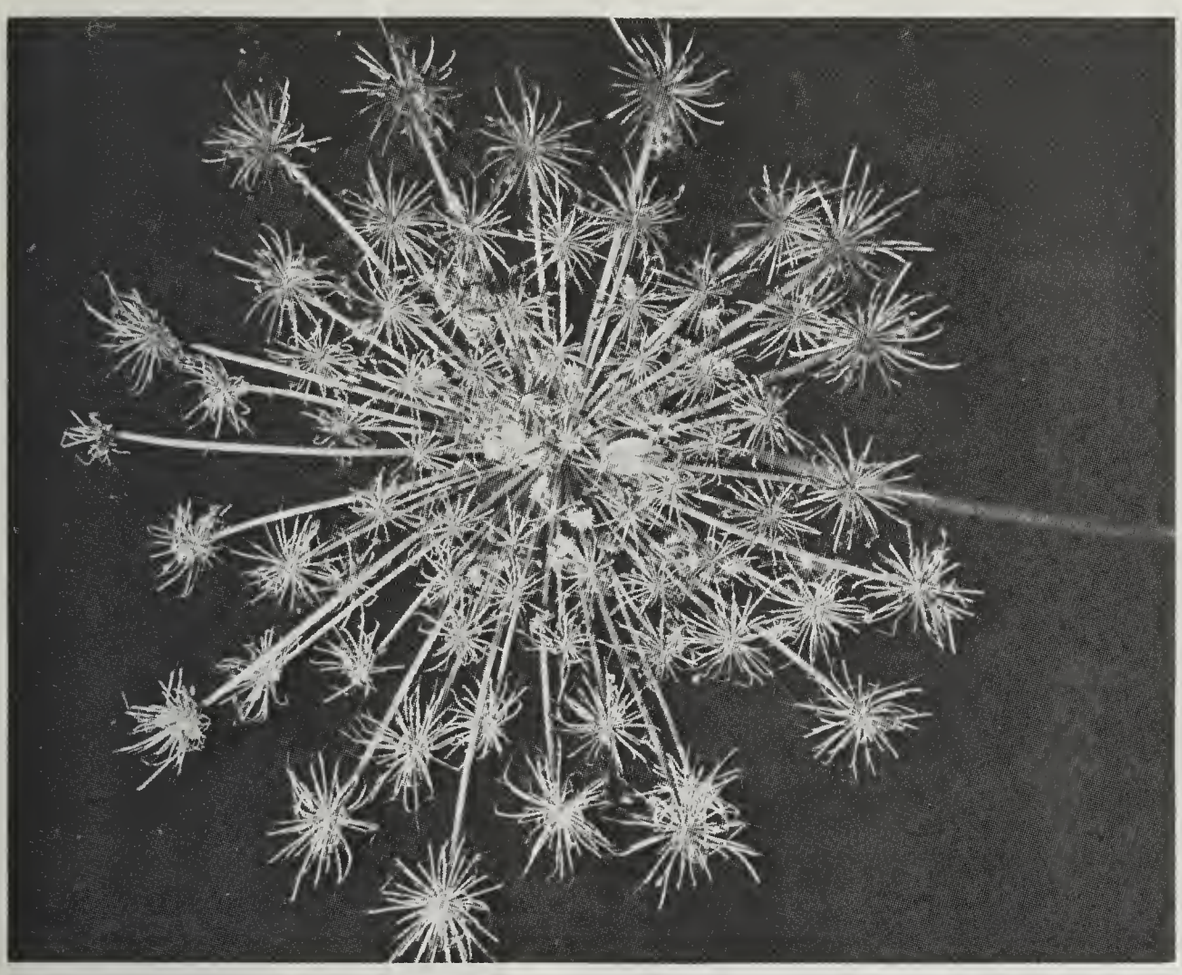
White Verbena James Pringle

Thistle Robert Campsmith, Kalamazoo Gazette

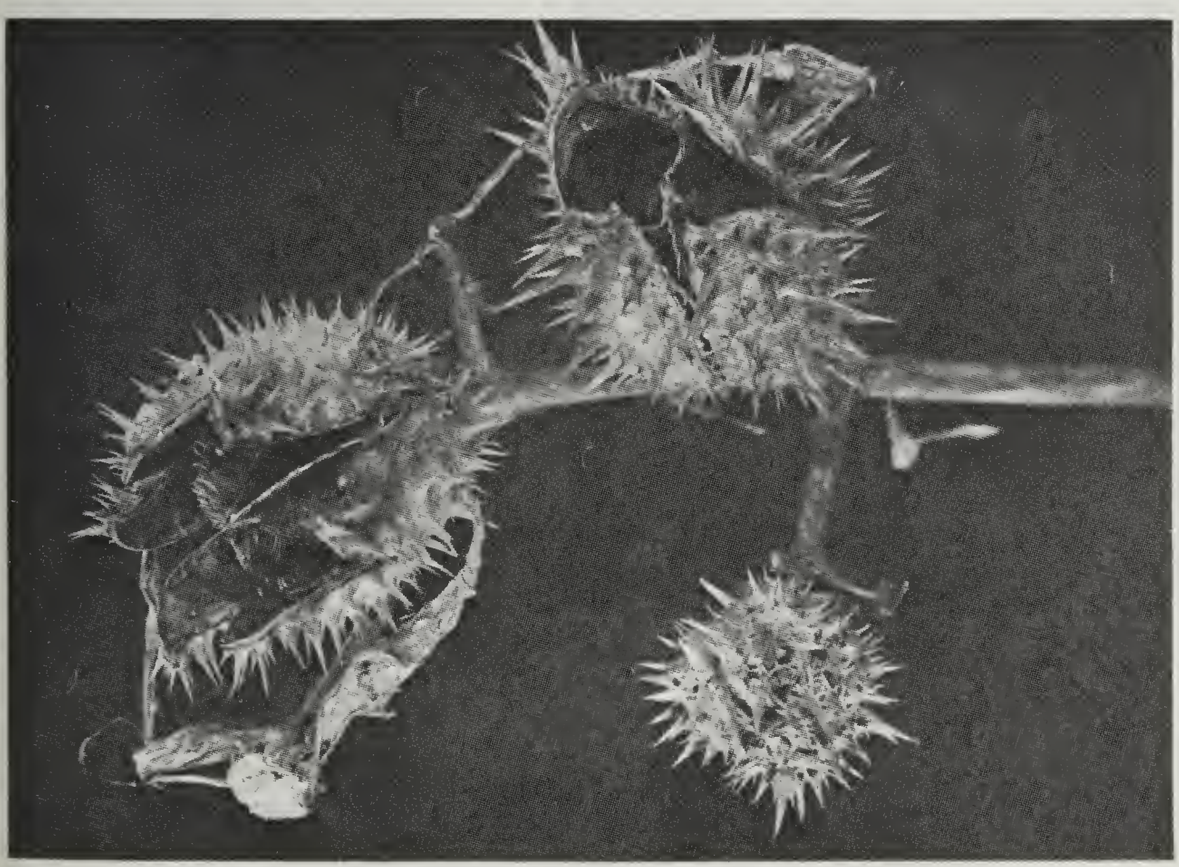


Common Milkweed

Henry Platz, Jr.



Queen Anne's-lace June Hicks



Jimsonweed James P. Bennett

Round-headed Bush Clover Henry Platz, Jr.

Wild Bergamot William Hopkins

Reed Alexander H. Smith

Review

NARRATIVE JOURNAL OF TRAVELS, through the Northwestern Regions of the United States Extending from Detroit through the Great Chain of American Lakes, to the Sources of the Mississippi River, Performed as a Member of the Expedition under Governor Cass. By Henry R. Schoolcraft. Facsimile reprint of the 1821 edition, by Arno Press. 1971 ["1970"]. 424 pp. $16.00.

Flowery narratives (with flowery titles) are less in style now than when this account was originally published, describing the first organized scientific expedition through Michigan (and into Minnesota, on an unsuccessful quest for the source of the Mississippi). It is fascinating reading, especially if one can transport himself back 150 years and imagine how the leaders of the Cass expedition must have thrilled on their first sight of such features as the Grand Sable dunes and the Pictured Rocks. Mackinac Island was a "refreshing spectacle . . . after a tedious voyage of fourteen days" by canoe from Detroit! Captain David Bates Douglass (whose journal has recently been published by Northern Michigan University) served officially as botanist. His collections were sent to Torrey, who published a list of them in the *American Journal of Science* for 1822. Some of the specimens are today in the herbarium of the New York Botanical Garden, including *Iris lacustris* collected at Presque Isle (Presque Isle Co.)—on June 5, while the expedition awaited a calming of the winds, as we learn from this narrative. Schoolcraft's own botanical observations must often be taken with a grain of salt. Surely Bois Blanc Island was never "in a great part covered" by *Liriodendron tulipifera,* which ranges nowhere near so far north in Michigan; it is equally doubtful whether the alluvial forests of the Ontonagon River did include walnut trees.

This volume and one reviewed on the next page are two of the 42 facsimile reprints in the "American Environmental Studies" series issued by Arno Press, a publishing and library service of The New York *Times*—in which latter publication one gets a great many more words for his money. The quality of reproduction is good, although a bit fuzzy in the Schoolcraft volume, presumably because it was for some reason reproduced from a microfilm copy.

—E. G. V.

Review: Two Superior Books

LAKE SUPERIOR: Its Physical Character, Vegetation, and Animals, Compared with Those of Other and Similar Regions. By Louis Agassiz. With a Narrative of the Tour, by J. Elliot Cabot. Facsimile reprint of the 1850 edition, by Arno Press. 1971 ["1970"]. 429 pp + 9 pl. $17.00.

SUPERIOR. Photographs by Charles Steinhacker; text . . . assembled and edited by Arno Karlen. Harper & Row, New York. n. d. [1970]. 117 pp. $25.00.

Separated by 120 years, these two works are not as far apart as might seem. The modern one is gloriously illustrated in color—but draws its text from the journals, diaries, and other writings of travelers before 1900, including the older volume and the one reviewed on p. 205. Having made at least brief excursions to the north shore of Lake Superior in each of 10 years, the past five with a class from the University of Michigan Biological Station, I am especially pleased to see in print (though at an unnecessarily inflated price) the account of Professor Agassiz's famous "class trip" of 1848. In three canoes and a Mackinaw boat, the party spent a month and a half along the Canadian shore of Lake Superior, studying first-hand the geology, botany, and zoology of the region—and lamenting the abundance of mosquitoes and black flies. Cabot's narrative, including the trip from Boston to the Sault, makes good reading and is full of informative tidbits: several place names are explained (e.g., "magpie" = the jay) and snow was noted deep in a chasm [Old Woman Bay?] on a hot July 7.

The scientific essays ending the volume include two of botanical concern: "The Northern Vegetation Compared with That of the Jura and the Alps" and "Observations on the Vegetation of the Northern Shores of Lake Superior." The brand-new first edition (1848) of Gray's Manual had been used for identification "on the spot," and collections were subsequently checked by Gray himself (whose brother-in-law, Charles G. Loring, Jr., a Harvard senior, was a member of the expedition). Many of the scientific names require up-dating, of course, but the lists are of interest as one of the earliest, though very incomplete, records of the boreal flora of the north shore. (Listing of *Echinodorus* is presumably the basis for the old indefinite records of this plant so far north; see Mich. Bot. 6: 16. 1967. One would also like to know where Agassiz found *Cakile* on the north shore, as the only Lake Superior records now known are from one beach on the south shore; see Mich. Bot. 2: 106-107. 1963.)

In contrast to Agassiz's orderly and classic treatise, we have a strikingly beautiful but totally unsystematic and unscientific picture-book, printed in Italy with superb rendition of color photographs. Anyone may pick this up and exclaim over it, no matter where he opens. Neither the pictures nor the passages selected for text have any relation to each other or to a logical geographic sequence, jumping back and forth all over the Lake in an apparently random manner. The photographs have little more than geographic identification. Waterlilies remain nameless, captioned only "Near Marathon, Ontario"; some uprooted and withering *Lycopodium clavatum* is merely "Rainbow Falls Provincial Park." The pictures are strong on sky and water effects, and one marvels at the patience (or was it only good fortune?) required to have a bird appear at just the right spot. Anyone could quibble over selection of scenes: why three pictures of ice pileups but none which do justice to the grandeur of the Pictured Rocks? The captions, continuity, and bibliography seem to have suffered from editorial haste, leading to errors and inconsistencies (e.g., "Brockaway" for Brockway; "Madelaine" Island on p. 68 but "Madeline" on p. 34).

Senator Gaylord Nelson's Foreword points out some of the threats to Lake Superior. The opening paragraph of the text observes that "today men can still see much of the lake as the early explorers and adventurers did—with the same wonder, and sometimes the same greed." Persons who would like to be in touch with some of the more gruesome facts about Lake Superior—and what is being done about them—should contact the Save Lake Superior Association, 242 W. Austin St., Duluth, Minnesota 55803. Membership (at $2.00) includes "Lake Superior News."

—E. G. V.

INDEX NOTICE
To Librarians, Subscribers, and Binders

There is no index to Vol. 10 of THE MICHIGAN BOTANIST. Cumulative indexes each covering three volumes were issued at the ends of volumes 3, 6, and 9, with the suggestion that each 3-volume unit be bound as one. The next cumulative index will be at the end of vol. 11 or vol. 12, depending on the size of these volumes.

Editorial Notes

Readers interested in the "Winter Wildflower" project of the Michigan Botanical Club are urged to participate this fall, so that the work may be brought to completion. See the feature on pp. 197-205 of this issue.

The May number (Vol. 10, No. 3) was mailed May 17, 1971.

Publications of Interest

WATER, WOODS AND WILDLIFE. Published monthly by Water, Woods and Wildlife, Box 145, Williams, Minnesota 56686. $3.00 per year; two years for $5.00. "Dedicated to the wise use of our natural resources, the continuation of quality hunting and fishing, and to informing the public about conservation matters," this new paper, published in northern Minnesota, is an "outdoor paper that places its emphasis on our fauna and flora." Although not sponsored by any conservation organization, the sample copies we have seen otherwise closely resemble the format of Michigan Out-of-Doors, published by Michigan United Conservation Clubs (MUCC). There are numerous feature articles of general interest to the outdoorsman in Michigan as well as in Minnesota.

The Newsletter of the Federation of Ontario Naturalists for June-July-August 1971 (Vol. 12, No. 3) includes a checklist of Ontario orchids (pp. 9-10) and a second set of revisions and additions to the checklist of vascular plants of the Bruce Peninsula (pp. 15-16).

Review

ATLAS OF UNITED STATES TREES Volume 1. Conifers and Important Hardwoods. U. S. Dep. Agr. Misc. Publ. 1146. 1971. 14 pp. + "200" maps + 9 overlays. $16.75, clothbound (Government Printing Office).

"This volume is the first of an atlas with large maps (mostly 12 in. x 11 in.) showing the natural distribution or range of the native tree species of continental United States including Alaska." Fortunately the maps indicate the Canadian range as well and are not chopped off at the international border. The work includes "200 maps" but since there may be as many as three for one species, plus inserted numbers (e.g., 22.1), the actual total is closer to 300. The title is interesting: presumably subsequent volumes will deal with "unimportant hardwoods"!

These are the culmination of a long series of Forest Service efforts toward accurate maps of tree distribution, and are certainly the best available. Based on critical published records, field notes, unpublished data, and herbarium specimens, the maps if anything strain so hard to avoid sins of commission (e.g., *Taxus canadensis*) that they may indicate too restricted a range for poorly collected areas, with white spaces scrupulously shown where no one has bothered to collect common species (as in the north-central Lower Peninsula of Michigan). The gymnosperm maps seem to have drawn heavily on the preliminary ones in Mich. Bot. 7: 121-128. 1968.

All species of native conifers are mapped, including both *Juniperus communis* and *J. horizontalis,* although the Cupressaceae are said (p. 1) to have only one shrub species. The overlays in a pocket include such features as drainage, topographic relief, plant hardiness zones, length of growing season, and precipitation–factors which may in some cases be of interest to correlate with tree distribution patterns.

–E.G.V.

CONTENTS

The Flora of Rock County, Wisconsin
Lytton J. Musselman, Theodore S. Cochrane,
William E. Rice, & Marion M. Rice 147

Pteridophytes of Beaver Island, Charlevoix County, Michigan
Lorraine Calhoun Veldman & Daniel E. Wujek 194

Nature Education Feature–
Wildflowers in Winter: A Project of the Michigan Botanical Club
Helen V. Smith 197

Review–Narrative Journal of Travels (Schoolcraft) 205

Review: Two Superior Books 206

Index Notice 207

Editorial Notes 207

Publications of Interest 207

Review–Atlas of United States Trees 207

(On the cover: Prairie white-fringed orchid, Habenaria leucophaea, *a rare species of wet-mesic prairies. From a color transparency taken in Rock County, Wisconsin, by H. H. Iltis, July 22, 1970. See page 166.)*

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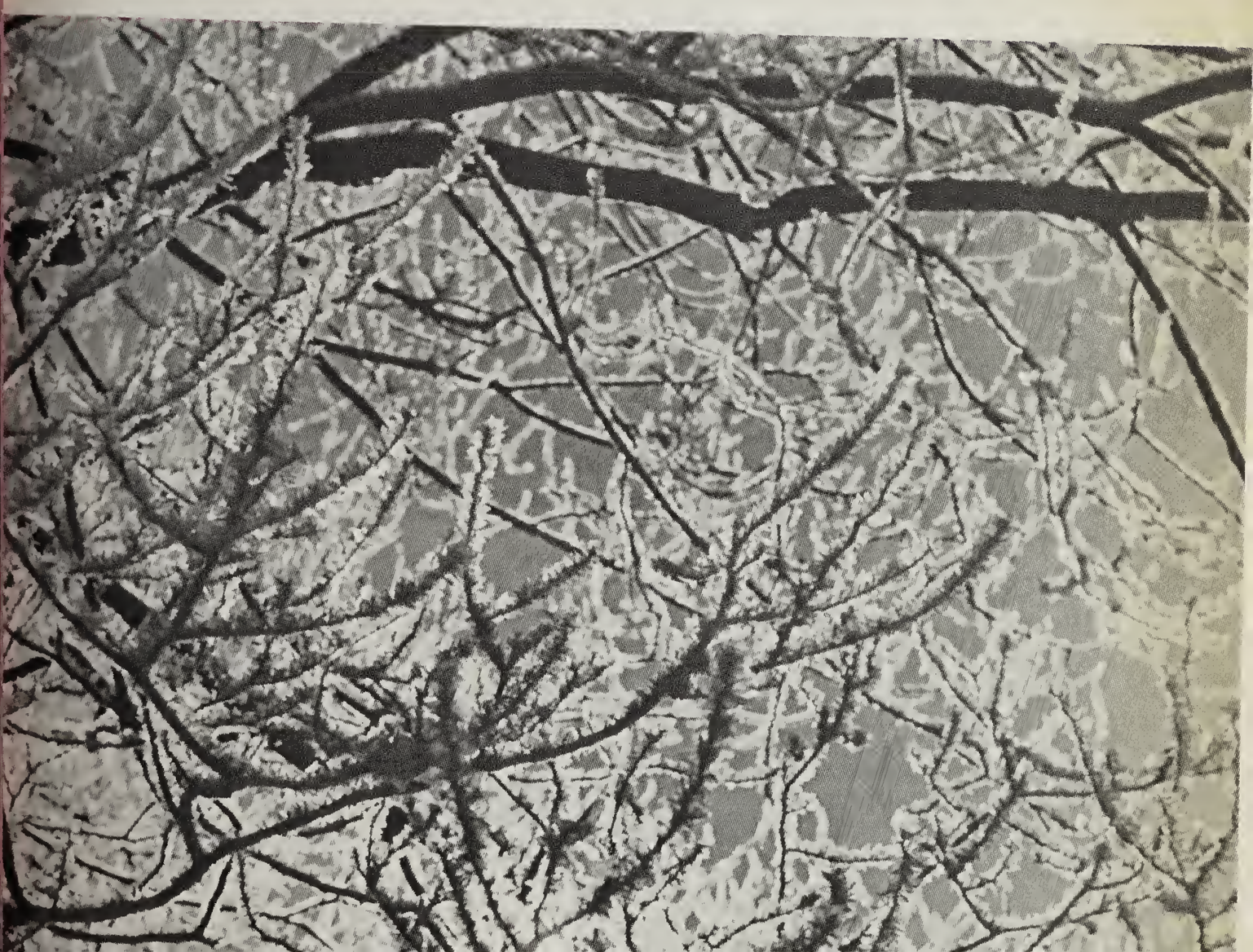
January, 1972



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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors should be guided by "Information for Authors" (Vol. 9, p. 62; copies available from the editor).

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THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter) may send $3.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

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A BRYOPHYTE FLORULA OF AN AREA NEAR GRAND LEDGE, EATON COUNTY, MICHIGAN

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Just northwest of the city of Grand Ledge, on both sides of the Grand River and along several of its tributaries, the Upper Pennsylvanian Eaton sandstone outcrops as a series of bluffs that at places rise to forty feet above the river. These natural exposures of bedrock (which otherwise are scarce in southern Michigan), a nearby abandoned quarry, and adjacent floodplain and upland forests harbor a rich and varied bryophyte flora, the subject of the following report.

The area studied centers on Fitzgerald Park (see Figure 1). Bluffs on the north side of the river from the dam upstream to the railroad trestle, those south of the river between the park and the trestle, and wooded tracts immediately west, northwest, and southeast of the park are also included. This area occupies parts of the eastern half of section 3 and the southwestern quarter of section 2, T. 4 N., R. 4 W., and is shown on the Portland, Michigan, 15-minute quadrangle (U.S. Geological Survey).

Two tributaries enter the Grand River from the south within the study area. One of these, Sandstone Creek, passes along the east side of the park and near the river is bordered by extensive exposures of shaded sandstone. Along the other, shaded slopes but only limited exposures occur. The second tributary flows across a small floodplain just before joining the river below the dam. An incompletely overgrown shale quarry, dug by the American Vitrified Products Company and abandoned about 1932 (Arnold, 1966), occurs southwest of the dam. Two small ponds occupy part of the quarry floor, and nearby, rust-brown spring waters seep toward the ponds producing an open, marshy site. Spoil banks are present at the north edge of the quarry, and along its southwestern border, a jumble of sandstone and conglomeratic sandstone boulders occurs on northeast facing slopes. Traces of a tramway, which entered the quarry from the south, can be found in the latter area. The bedrock geology of this and other quarries near Grand Ledge, famous for their well-preserved compression flora of Pennsylvanian age, is treated in detail by Kelly (1933, 1936).

Apart from the more inaccessible bluffs, the vegetation of the entire area surveyed has been modified by partial or complete clearing or by quarrying. Further, the numerous, scenic trails along the bluffs show signs of heavy current usage. However, an indication of the kind of original forest that grew above the river can be found within Fitzgerald Park, a portion of which is occupied by a remnant beech-maple stand. Individual trees of *Fagus grandifolia* and *Acer saccharum* dominate this stand and *A. rubrum, Fraxinus americana, Prunus serotina, Quercus rubra* (abundant), and other species of

trees are also present. Unfortunately, understory saplings and herbs mostly have been removed. Along Sandstone Creek and at a few places on the north side of the river and elsewhere, eastern hemlock (*Tsuga canadensis*) grows in some abundance, one of only a few occurrences of this species in south-central Michigan.

Slopes along the river are wooded and contain somewhat more oak (both *Quercus alba* and *Q. rubra*) than upland areas. Ferns are abundant on shaded sandstone ledges, and at one place, two colonies containing somewhat over 150 rosettes (on March 19, 1969) of the predominantly northern birdseye primrose, *Primula mistassinica*, occur on exposed, damp, vertical

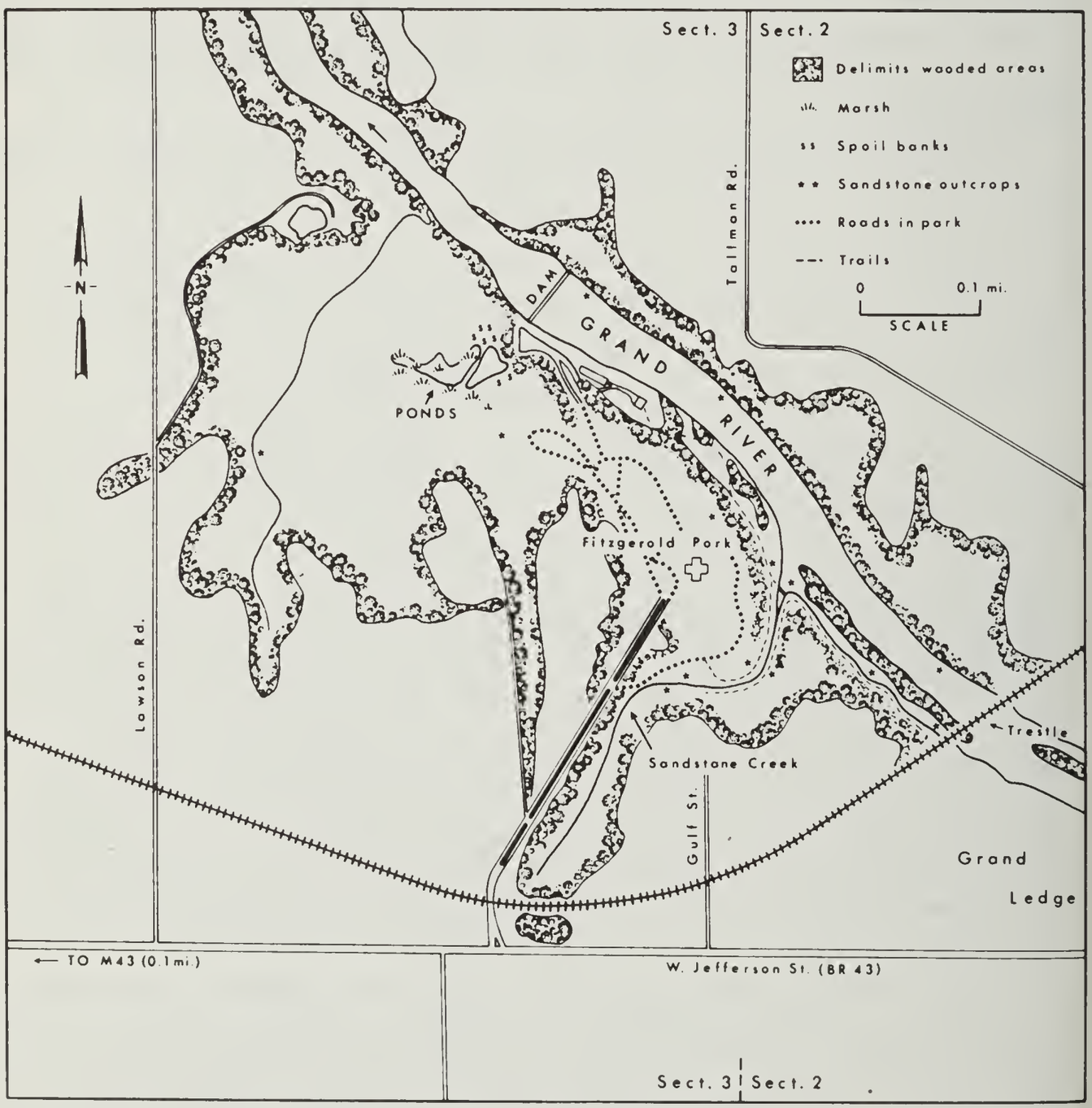

Fig. 1. Fitzgerald Park and surrounding areas. Roads in park and course of tributary below dam approximate. Two small sewage basins have recently been dug immediately east of the ponds and are not shown. [Drawn from part of an enlarged 26″ X 26″ print of an aerial photograph (BDL-1HH-142, USDA Agricultural Stabilization and Conservation Service) taken September 12, 1967.]

sandstone. This is one of the southernmost stations, and the most inland one, for this species in Michigan. On the floodplain south of the river *Acer saccharinum* and *Populus deltoides* are prominent trees. However, the best development of floodplain forest occurs at the mouth of the tributary below the dam. Large individuals of *Ulmus americana* (now mostly dead or dying from Dutch elm disease) are present and associated trees include *Gymnocladus dioica* (abundant near the river), *Acer saccharinum, Populus deltoides,* and *Tilia americana.* The alluvium in this area supports a diverse flora of spring-flowering herbs.

Revegetation of the clayey soil of the quarry and adjacent tracts has proceeded to the point where hardwood saplings or seedlings occur in most areas. However, *Populus tremuloides* remains the most abundant tree throughout the quarry area. Along the north and east sides of the pond nearest the dam, a population of *Sphagnum recurvum* has become established in shallow water and on the bank. Measurements with a Beckman pocket pH meter (model 180) on April 7, 1968, revealed that in this area pond water acidity varied from 3.9 (shallow water with *S. recurvum* emergent, east side), to 4.2 (wet terrestrial mat of *S. recurvum,* east side), to 5.0 (shallow water with *S. recurvum* emergent, north side). At the opposite end of the pond where no *Sphagnum* grows values ranged from 6.8 to 8.0. In the nearby marsh measurements of pH varied from a low of 3.4 (in a wet mat of *S. recurvum*) to a maximum of 7.0 (in a mat of the moss *Calliergonella cuspidata, Sphagnum* absent). Moving water in the spring had a pH of 6.6.

The forest immediately east of the quarry is secondary in nature. Trees of small to medium diameter, mainly *Acer rubrum, Ostrya virginiana, Prunus serotina, Quercus rubra,* and *Tilia americana,* occur on the upland, although the character of the stand changes as the topography slopes toward the unnamed tributary. The slopes support *Acer saccharum, Fagus grandifolia,* some *Tsuga canadensis,* and other species of trees.

The sandstone bluffs near Grand Ledge early received attention from botanists. The first bryophyte collections I have found from the area are those of C. F. Wheeler who, according to specimen label data, visited the bluffs several times between 1890 and 1892. Professor W. J. Beal of what was then Michigan Agricultural College and now is Michigan State University, 13 miles to the east, also botanized in the area, presumably at about this time. Important subsequent collectors include W. C. Steere and H. R. Becker (jointly or independently) and H. T. Darlington, who made extensive collections at Grand Ledge in 1945 and lesser ones in 1951 and 1954. Dr. Darlington's manuscript notes, which are on file at the Michigan State University Herbarium, indicate his interest in the bryophyte flora of the area and include several lists of species he and others had found there. More recently, various students from Michigan State collected at the bluffs, and Redfearn and Halbert (1969) reported on noteworthy species they found in the area while associated with the W. K. Kellogg Biological Station of Michigan State University. My studies of the area began in the spring of 1964 and continued sporadically through the spring of 1971.

THE BRYOPHYTE FLORA

While the area surveyed is relatively small (*ca.* 0.2 sq. mi.), its diverse habitats support a large bryophyte flora–40 species of Hepaticae and 114 species and 8 varieties of Musci including *Sphagnum.* One moss, *Fissidens exilis,* is here first reported from Michigan. Most of the flora is characteristic of forest areas in temperate eastern North America (and often elsewhere in the North Temperate Zone) but a number of species are near the northern or southern limits of their range. The overlapping of northern and southern species of vascular plants in the Grand River valley was early pointed out by Beal and Wheeler (1892), and the occurrence of bryophytes with similar geographical affinities is fully expected, particularly in view of the favorable edaphic and microclimatic features of the sandstone bluffs and surrounding habitats. The northern element in the flora is clearly better represented than the southern and includes *Bryum angustirete, Encalypta ciliata, Oncophorus wahlenbergii, Ptilidium ciliare, Rhytidiadelphus triquetrus, Tomenthypnum nitens, Trichostomum tenuirostre,* and others; among species of predominantly southern distribution are *Brotherella tenuirostris, Isopterygium distichaceum, Sematophyllum carolinianum,* and *Taxiphyllum deplanatum.* The sandstone itself supports many species found in sandstone gorge areas to the south but which otherwise are of fairly limited distribution in this region (e.g., east-central Indiana; see lists in Miller & Thompson, 1959).

The catalogue which follows is based primarily on my own collections and those available at the Michigan State University Herbarium (MSC) and at the Herbarium of The University of Michigan (MICH). Dr. Darlington's manuscript lists and the Eaton County records in *The Mosses of Michigan* (Darlington, 1964) and other publications (Steere, 1934-1942) have been used to guide retrieval of specimens from both herbaria, but otherwise the bryophyte collection at MSC has been thoroughly searched for additional records. Only identifications I have been able to confirm are included; previously reported species which must be excluded for one reason or another are listed at the end of the catalogue. The collections cited are my own unless noted otherwise, and specimens not at MSC or MICH are in my personal herbarium. If greater than one, the number of collections of a species seen by me is given in a bracketed abbreviation at the end of the citations. In general this figure indicates the abundance of a species in the area. Records for Eaton County or southern Michigan not included in Darlington (1964), Steere (1940), or reported by others (see literature cited) are preceded by an asterisk.

HEPATICAE

Ptilidium ciliare (L.) Dumort.–Top of small sandstone cobble, *3844.*

P. pulcherrimum (Web.) Hampe–Rock, *3054A* (MSC); rotted log at soil level, quarry, *Engel 3670* (MSC). [5 coll.]

Blepharostoma trichophyllum (L.) Dumort.–Soil over rock, *Steere s. n.* (MICH).

Lepidozia reptans (L.) Dumort.–Fitzgerald Park, *Wetmore 2630a* (MSC).

Calypogeia fissa (L.) Raddi–Sandy bank, cut leading to river, *5065.* [3 coll.]

**Cephalozia bicuspidata* (L.) Dumort.–Soil layer over rock, quarry, *Engel 3675 p. p.* (MSC).

C. media Lindb.–Sandy soil and sandstone cobbles along unnamed tributary, *5878.*

C. pleniceps (Aust.) Lindb.–Sandy humus over decaying sandstone, *3839* (MSC).

Nowellia curvifolia (Dicks.) Mitt.–Creeping over *Jamesoniella autumnalis* on rock in small depression, *Engel 3662B* (MSC).

Cladopodiella fluitans (Nees) Joerg.–Wet peaty soil, edge of pond, *2981* (MSC).

Cephaloziella hampeana (Nees) Schiffn.–Soil layer over rock, quarry, *Engel 3675 p. p.* (MSC).

**C. rubella* (Nees) Dumort.–With *Dicranum fulvum,* face of sandstone bluff, *4472 p. p.*

Lophocolea heterophylla (Schrad.) Dumort.–Moist clay and shale fragments, *2988* (MSC); soil bank, *Engel 3650* (MSC). [9 coll.]

L. minor Nees–With lichens on sandstone boulder, *3057 p. p.* (MSC). [2 coll.]

Chiloscyphus pallescens (Ehrh.) Dumort.–Moist mud and shale fragments, slope, *2986* (MSC); sandstone boulder along creek, *4500.*

Geocalyx graveolens (Schrad.) Nees–With lichens on sandstone boulder, *3057 p. p.* (MSC). [7 coll.]

**Lophozia bicrenata* (Schmid.) Dumort.–Rock, quarry, *Engel 3684* (MSC).

**L. capitata* (Hook.) K. Müll.–Wet soil near marsh, *2982.* [3 coll.]

**L. excisa* (Dicks.) Dumort.–Soil, steep bank, *Steere 452* (MICH). [2 coll.]

**L. incisa* (Schrad.) Dumort.–Fitzgerald Park, *Wetmore 2637* (MSC).

Jungermannia leiantha Grolle–Tightly appressed to face of sandstone bluff, gemmiparous, *4461* (MICH); soil, *Steere s. n.* (MICH). [4 coll.]

Jamesoniella autumnalis (DC.) Steph.–Sandy soil over sandstone, *4475 p. p.* (MSC); sandy humus, bank along river, *Becker s. n.* (MICH). [6 coll.]

**Solenostoma crenuliformis* (Aust.) Steph.–Shaded bank, *Steere 454,* as *Nardia hyalina* (MICH).

**S. gracillimum* (Sm.) Schust. [*Plectocolea crenulata* (Sm.) Evs.]–Moist clay bank, *2984* (MSC); decaying sandstone rock, *3841* (MSC). [9 coll.]

S. pumilum (With.) K. Müll.–Wet vertical sandstone, *Steere 456* (MICH).

Plagiochila asplenioides (L.) Dumort.–Face of sandstone bluff, *4463* (MSC); moist soil, *Steere 458* (MICH). [6 coll.]

**Diplophyllum apiculatum* (Evs.) Steph.–Thin soil over sandstone, sw-facing bank, *5069.*

Scapania nemorosa (L.) Dumort.–Moist sand over sandstone, *4477.* [4 coll.]

**Porella platyphylla* (L.) Lindb.–Trunk of *Ulmus* sp., n-facing slope, *4501*; soil, summit of n-facing slope, *4502* (MSC). [3 coll.]

Radula complanata (L.) Dumort.–Grand Ledge, *Darlington s. n.* (MSC).

Frullania eboracensis Gottsche–Bark of living *Acer saccharum* along unnamed tributary, *5877.*

Lejeunea cavifolia (Ehrh.) Lindb.–Exposed rock, *Steere 457* (MICH).

Pellia epiphylla (L.) Corda–Moist soil, *2983;* moist sandstone, *3053* (MSC). [6 coll.]

**P. neesiana* (Gottsche) Limpr.–Sandy mound, edge of marsh, *3840.*

Riccardia latifrons Lindb.–Moist side of sandstone boulder, *3055* (MSC); decorticated log, *3842* (MSC). [3 coll.]

R. pinguis (L.) S. F. Gray–Alluvial soil along unnamed tributary, *3843* (MSC).

Marchantia polymorpha L.–Thin moist soil, side of fissure in sandstone bluff, *4462.* [2 coll.]

Conocephalum conicum (L.) Dumort.–Alluvial soil along unnamed tributary, *3838* (MSC); soil over sandstone, *Engel 3651B* (MSC). [8 coll.]

Reboulia hemisphaerica (L.) Raddi–Thin soil over ledge in sandstone bluff, *4464* (MSC). [10 coll.]

Phaeoceros laevis (L.) Prosk.–Wet vertical rock, *Steere 459* (MICH). [2 coll.]

MUSCI

**Sphagnum capillaceum* var. *tenellum* (Schimp.) Andrews–Edge of marsh, *4512* (MSC). [2 coll.]

**S. centrale* C. Jens.–Same, *3869.*

**S. fimbriatum* Wils. ex Hook. f.–Same, *4513* (MSC).

**S. fuscum* (Schimp.) Klingrr.–Marsh, *3030* (MSC).

**S. girgensohnii* Russ.–Moist bank near marsh, *3033* (MSC).

**S. magellanicum* Brid.–Marsh, *3032* (MSC).

**S. recurvum* P. Beauv.–Edge of marsh, *3031* (MSC). [3 coll.]

**S. squarrosum* Crome–Moist bank near marsh, *3870*; in water, edge of marsh, *4514.* [3 coll.]

**Fissidens exilis* Hedw.–Moist clayey soil with *F. viridulus,* spoil bank beneath sparse tree cover, *4507 p. p.* (MSC). New to Michigan. A minute species with only two to four pairs of leaves, *F. exilis* can be readily identified on the basis of its distinctive vaginant laminae, which have a submarginal border of irregularly elongate cells (see W. C. Steere, Bryologist 53: 131-136. 1950). Spore liberation in this *Fissidens* takes place in the early spring and the typically numerous sporophytes with their bright red or orange-red peristome teeth are conspicuous at this time of year. In addition to the Michigan locality, I have seen specimens of *F. exilis* from Iowa, New York State (widespread south of the Adirondack Mts.), and Maryland, and reports (H. Crum, in litt.) from Ohio and Pennsylvania. Damp, bare, often clayey soil, usually in woodlands, but sometimes along roadsides, are habitats most frequently mentioned on specimen labels. Owing to its minute size and apparently weedy behavior (although the Grand Ledge station has persisted for at least three years between 1968 and 1971), the species probably has been overlooked and should be sought elsewhere in North America.

F. minutulus Sull.–Sandstone cobble, *4480.* [2 coll.]

F. taxifolius Hedw.–Alluvial soil along unnamed tributary, *3859* (MSC). [2 coll.]

**F. viridulus* (Sw.) Wahlenb.–Moist clayey soil, spoil bank, *4507 p. p.* (MSC).

**Pleuridium subulatum* (Hedw.) Rabenh.–Bare ground between grass clumps, summit of bluff, *5071.*

Ditrichum pallidum (Hedw.) Hampe–Waste ground near RR trestle, *5068.*

Ceratodon purpureus (Hedw.) Brid.–Clayey soil, trailside, *3849* (MSC); concrete dam abutment, *5041.* [7 coll.]

Trematodon ambiguus (Hedw.) Hornsch.–Moist, open clay ground, *Darlington 646* (MSC).

Dicranella heteromalla (Hedw.) Schimp.–Side of sandstone boulder, *3851* (MSC); along river in park, *Wetmore 821* (MSC). [11 coll.]

**Oncophorus wahlenbergii* Brid.–Dry sandstone rock, *3042* (MSC).

**Dicranum flagellare* Hedw.–Top of sandstone boulder, *3852* (MSC).

D. fulvum Hook.–Face of sandstone bluff, *4472 p. p.*

D. montanum Hedw.–Grand Ledge, *Darlington s. n.* (MSC); base of *Fagus* along unnamed tributary, *5875.*

**D. polysetum* Sw.–Side of moist sandstone boulder, slope above marsh, *4518* (MSC).

D. scoparium Hedw.–Bank above marsh, *3853* (MSC). [3 coll.]

Leucobryum glaucum (Hedw.) Ångstr. ex Fr.–Along Sandstone Creek, *Darlington s. n.* (MSC).

Encalypta ciliata Hedw.–Grand Ledge, *Wheeler 129* (MSC).

Weissia controversa Hedw.–Moist soil along road, *3871*; tightly appressed to face of sandstone bluff, *4484*. [8 coll.]

Gymnostomum aeruginosum Sm. [*G. rupestre* Schleich. (Nichols, 1932)]–Side of moist sandstone boulder along stream, unnamed tributary, *3864;* face of sandstone bluff, *4481* (MSC).

G. recurvirostrum Hedw.–Moist face of sandstone bluff, *5043A*. [4 coll.]

**Trichostomum tenuirostre* (Hook. & Tayl.) Lindb.–Moist sandstone ledge along Sandstone Creek, *5064 p. p.*

Didymodon tophaceus (Brid.) Lisa–Dripping sandstone bluff, *5046* (MICH).

**Bryoerythrophyllum recurvirostrum* (Hedw.) Chen–Ledge in sandstone bluff, *4488*. [2 coll.]

Barbula fallax Hedw.–Moist sandstone ledge along Sandstone Creek, *5064 p. p.*

B. unguiculata Hedw.–Ground, *Darlington 9* (MSC).

**Phascum cuspidatum* Hedw.–Soil along river, with *Funaria hygrometrica, Darlington s. n.* (MSC).

Desmatodon obtusifolius (Schwaegr.) Schimp.–Face of sandstone bluff, *4468*. [2 coll.]

Grimmia alpicola var. *rivularis* (Brid.) Wahlenb.–Igneous boulder along unnamed tributary, *4493* (MSC). [2 coll.; *G. alpicola* Hedw. var. *alpicola* reported from stone walls by Redfearn & Halbert (1969).]

**Physcomitrium pyriforme* (Hedw.) De Not.–Ground, *Darlington 556 p. p.* (MSC).

Funaria hygrometrica Hedw.–Soil along river, with *Phascum cuspidatum, Darlington s. n.* (MSC).

Tetraphis pellucida Hedw.–Sandy bank, cut leading to river, *5066*. [2 coll.]

**Pohlia annotina* var. *loeskei* Crum, Steere, & Anders.–Soil over sandstone boulder at base of bluff, *4486* (MSC).

P. nutans (Hedw.) Lindb.–Wet peaty soil, edge of marsh, *3039* (MSC); ground, *Darlington 556 p. p.* (MSC). [4 coll.]

P. wahlenbergii (Web. & Mohr) Andrews–Marsh, *3862* (MSC); moist sandstone ledge along Sandstone Creek, *5061*. [6 coll.]

Leptobryum pyriforme (Hedw.) Wils.–Crevice, sandstone bluff, *4469*. [2 coll.]

Bryum angustirete Kindb. ex Mac.–Sandstone, *Redfearn 22362* (MICH).

**B. argenteum* Hedw.–Soil, roadside, *4466* (MSC).

**B. capillare* Hedw.–Igneous boulder along creek, *4496 p. p.*

B. caespiticium Hedw.–Ground, *Darlington s. n.* (MSC).

Mnium affine Bland ex Funck–Moist soil along creek, *4499* (MSC).

M. cuspidatum Hedw.–Sandstone cobble, *3860* (MSC). [3 coll.]

M. marginatum (With.) Brid. ex P. Beauv.–Face of moist sandstone bluff, *4483* (MSC).

M. orthorrhynchum Brid.–Grand Ledge, *Darlington s. n.* (MSC).

M. punctatum Hedw. var. *punctatum*–Sandy bank, cut leading to river, *5066*. *Var. *elatum* Schimp.–Wet soil, marsh, *5874*.

Aulacomnium heterostichum (Hedw.) B.S.G.–Summit of n-facing slope, *4509* (MSC). [5 coll.]

A. palustre (Hedw.) Schwaegr.–Hummock in marsh, *3846* (MSC). [2 coll.]

**Bartramia pomiformis* Hedw.–Among loose rocks on ne-facing slope, *4519* (MSC). [3 coll.]

**Philonotis fontana* (Hedw.) Brid.–Grand ledge, *Wheeler 151* (MSC).

**Orthotrichum obtusifolium* Brid.–Bark of *Ulmus americana,* unnamed tributary, *4520 p. p.* (MSC).

**O. pumilum* Sw.–Same, *4520 p. p.* (MSC). [2 coll.]

Climaeium amerieanum Brid.–Ground, *Darlington 562* (MSC).

**Hedwigia ciliata* (Hedw.) P. Beauv.–Along river in park, *Wetmore 838* (MSC).

Myurella sibirica (C. Müll.) Reim.–Tightly appressed to face of sandstone bluff, *4484.* [3 coll.]

Leskea graeilescens Hedw.–Bark of living *Populus deltoides, 4491.*

**Leskeella nervosa* (Brid.) Loeske–Soil on sandstone ledge, *4473.*

Anomodon attenuatus (Hedw.) Hüb.–Bark of *Ulmus* near base of tree, *3845* (MSC); boulder along Sandstone Creek, *Darlington 13* (MSC). [4 coll.]

**A. rostratus* (Hedw.) Schimp.–Under moist, overhanging sandstone ledge, *4465* (MSC). [2 coll.]

**Thuidium delicatulum* (Hedw.) B.S.G.–Moist litter and soil, quarry, *3048* (MSC).

**T. recognitum* (Hedw.) Lindb.–Dry soil among grasses, *3046* (MSC). [2 coll.]

Cratoneuron filieinum (Hedw.) Spruce–Encrusted at base of dripping sandstone bluff, *5040.* [3 coll.]

**Campylium ehrysophyllum* (Brid.) J. Lange–Moist soil, bank, *3872* (MSC).

**C. hispidulum* (Brid.) Mitt.–Bark at base of living *Fraxinus americana, 4494 p. p.*

**C. polygamum* (B.S.G.) C. Jens.–Quarry, *Erbisch 66* (MSC).

**Leptodictyum triehopodium* var. *koehii* (B.S.G.) Broth.–Soil, *Darlington s. n.* (MSC).

Hygroamblystegium fluviatile (Hedw.) Loeske var. *fluviatile*–Wet sandstone rock along creek, *4497* (MSC). [2 coll.]. *Var. *orthoeladum* (P. Beauv.) Crum, Steere, & Anders.–Sandstone boulder, *4490.*

**Amblystegium juratzkanum* Schimp.–Ground, *Darlington 557* (MSC).

**A. serpens* (Hedw.) B.S.G.–Along river in park, *Wetmore 819* (MSC).

A. varium (Hedw.) Lindb.–Bark at base of living *Fraxinus amerieana, 4494 p. p.;* moist face of sandstone bluff, *5074.* [7 coll.]

Drepanoeladus aduncus (Hedw.) Warnst. var. *aduncus*–Submerged in marsh, *3865* (MSC); concrete dam abutment, ± inundated, *5038.* [3 coll.]. *Var. *polycarpus* (Bland. ex Voit) Roth–Wet rock at edge of marsh, *3043.*

Calliergonella cuspidata (Hedw.) Loeske–Marsh, *3041* (MSC). [5 coll.]

Tomenthypnum nitens (Hedw.) Loeske–Ground, *Darlington 563* (MSC).

Brachythecium aeuminatum (Hedw.) Rau & Herv.–Top of boulder along Sandstone Creek, *Darlington 77* (MSC).

B. oxyeladon (Brid.) Jaeg. & Sauerb.–Clayey bank, *3867.* [4 coll.]

B. plumosum (Hedw.) B.S.G.–Along river in park, *Wetmore 816* (MSC). [3 coll.]

B. rivulare B.S.G.–Moist soil, stream bank, *4495* (MSC).

**B. rutabulum* (Hedw.) B.S.G.–Sandstone cobble, *3854* (MSC); moist soil, bank, *3873* (MSC). [3 coll.]

B. salebrosum (Web. & Mohr) B.S.G.–Moist soil, slope, *4508* (MSC). [2 coll.]

Brylnia graminieolor (Brid.) Grout–Rock, *Darlington s. n.* (MSC).

**B. novae-angliae* (Sull. & Lesq. ex Sull.) Grout–Soil at top of sandstone bluff, *4474.*

Rhynchostegium serrulatum (Hedw.) Jaeg. & Sauerb.–Ground, *Darlington 560* (MSC); rock, *Darlington s. n.* (MSC).

Rhynehostegiella compaeta (C. Müll.) Loeske–Sandstone bluff, *Redfearn 22354* (MICH).

**Eurhynchium hians* (Hedw.) Sande Lac–Humus and alluvial soil along unnamed tributary, *4517* (MSC).

**E. pulehellum* (Hedw.) Jenn.–Moist sandstone cobble, *3038* (MSC); ground, *Darlington 532* (MSC).

Entodon seduetrix (Hedw.) C. Müll.–Sandstone cobbles, *3857.* [4 coll.]

**Pleurozium schreberi* (Brid.) Mitt.–Over dry rock, *3037* (MSC); shaded bank above marsh, *3861* (MSC). [4 coll.]

Plagiothecium denticulatum (Hedw.) B.S.G.–Forming thick mats on boulders along Sandstone Creek, *Darlington 27* (MSC). [3 coll.]

P. roeseanum B.S.G.–Soil, bank below sandstone bluff, *4470* (MSC); ledge in sandstone bluff, *4485.* [4 coll.]

Heterophyllium haldanianum (Grev.) Kindb.–Sandstone cobble, *3866* (MSC). [5 coll.]

Brotherella tenuirostris (Bruch & Schimp. ex Sull.) Broth.–Face of sandstone boulder, Sandstone Creek, *4479.* [3 coll.]

Sematophyllum carolinianum (C. Müll.) E. G. Britt.–Vertical sandstone, *Redfearn 22393* (MICH).

Platygyrium repens (Brid.) B.S.G.–Thin soil over sandstone, *4471* (MSC); bark of *Ulmus* sp., *4492.*

**Homomallium adnatum* (Hedw.) Broth.–Igneous boulder along creek, *4496 p. p.* [2 coll.]

**Hypnum curvifolium* Hedw.–Dry tops of rocks, *3047* (MSC); sandstone boulder, marsh, *4510.*

**H. lindbergii* Mitt.–Moist sandstone rock, *3040* (MSC); soil, edge of marsh, *3855* (MSC).

Isopterygium distichaceum (Mitt.) Jaeg. & Sauerb. [*I. subfalcatum* (Aust.) Jaeg. & Sauerb. (Crum, 1970)]–Moist earth in open woods, *Darlington 8* (MSC).

Taxiphyllum deplanatum (Sull.) Fleisch.–Soil, *Darlington s. n.* (MSC).

**Rhytidiadelphus triquetrus* (Hedw.) Warnst.–Sandstone rock, *3049* (MSC).

**Buxbaumia aphylla* Hedw.–Moist sandstone rocks, *3045* (MSC).

Diphysium foliosum (Hedw.) Mohr–Sandy soil, sw-facing bank, *5072.*

**Atrichum altecristatum* (Ren. & Card.) Irel.–Dry soil among sandstone boulders, *3044* (MSC). [4 coll.]

A. angustatum (Brid.) B.S.G.–Boulder, *Darlington 23* (MSC); sandy soil, *5075.* [7 coll.]

**A. oerstedianum* (C. Müll.) Mitt.–Moist ground along Sandstone Creek, *Darlington 652* (MSC).

**Polytrichum commune* Hedw.–Along edge of pond, *Darlington 72* (MSC). [2 coll.]

P. juniperinum Hedw. var. *juniperinum*–Sandy banks, *Parmelee 137* (MSC). [2 coll.]. *Var. *gracilius* Wahlenb.–Marsh, *3036* (MSC).

P. ohioense Ren. & Card.–Sandy soil over sandstone, *4475 p. p.* (MSC). [3 coll.]

P. piliferum Hedw.–Clayey sand, bank, *3863* (MSC); thin sand over bluff, *4487* (MSC). [3 coll.]

EXCLUDED SPECIES

Specimens of the following species reported to occur at Grand Ledge could not be located at MSC or MICH, and these records are therefore not accepted: *Fissidens obtusifolius* Wils. (Steere, 1942), *Pottia truncata* (Hedw.) Fürnr. ex B.S.G. (Darlington, 1964, Eaton Co. record only, but Grand Ledge in his notes), and *Preissia quadrata* (Scop.) Nees (Steere, 1940). Elimination of others is based on revised identifications. Specimens of *Atrichum undulatum* (Hedw.) P. Beauv. from the area (Darlington, 1964) can all be referred to other species of *Atrichum*; material of *Fissidens bushii* (Card. & Thér.) Card. & Thér. (Crum & Miller, 1968) actually is *F. taxifolius; Gymnostomum calcareum* Nees, Hornsch. & Sturm (Steere, 1942) is based on a collection of *G. aeruginosum;* and the report of *Plectocolea hyalina* (Lyell) Mitt. (Steere, 1934, 1940) is based on material of *Solenostoma crenuliformis.*

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I thank Dr. Howard Crum for determining a number of difficult moss specimens from the Grand Ledge area and also for confirming many of my identifications. Drs. L. E. Anderson and R. R. Ireland have been similarly helpful.

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Review

COMMON WILD FLOWERS OF MINNESOTA. Illustrations by Wilma Monserud; text by Gerald B. Ownbey. University of Minnesota Press, Minneapolis, 1971. 331 pp. $9.75.

This book devotes much more space to each species than does the new one on Ohio wild flowers (review, p. 37). 325 species are illustrated, mostly on half-page plates with text beside (on an oblong 8½ X 6½″ page, bound on the narrow edge). The price averages exactly three cents per species—over four times as much as the Ohio volume. No woody plants are included, no grasses, and only one sedge, although there are three pondweeds. The selection of species, however, is fairly representative and includes some weeds as well as familiar wildflowers and some often neglected plants, such as *Wulfenia bullii.* The families are arranged alphabetically by their scientific names within the monocots and dicots, an arrangement which may not help the amateur who doesn't know the family names anyway (or knows different names for the families). The illustrations are attractive, and frequently include details as well as the oft-overlooked underground parts. The text includes comments on color, habitat, and distribution in Minnesota. Sometimes there is mention of similar species; with only a few more words, additional species could have been mentioned without sacrificing too much of the generous open format. There is a fairly extensive glossary which ought to be useful and which appears, indeed, to include some words avoided in the text.

—E. G. V.

STUDIES IN THE GENUS *CORTINARIUS*, II: SECTION DERMOCYBE, NEW AND INTERESTING SPECIES FROM MICHIGAN

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INTRODUCTION

During the last four years we have been making a taxonomic study of the *Dermocybe* flora of North America. As in other groups of fleshy fungi, including the genera *Galerina, Pholiota,* and *Hygrophorus,* we have found that the limits of previously described or recorded species are not well defined in terms of North American specimens and that there are a number of undescribed species.

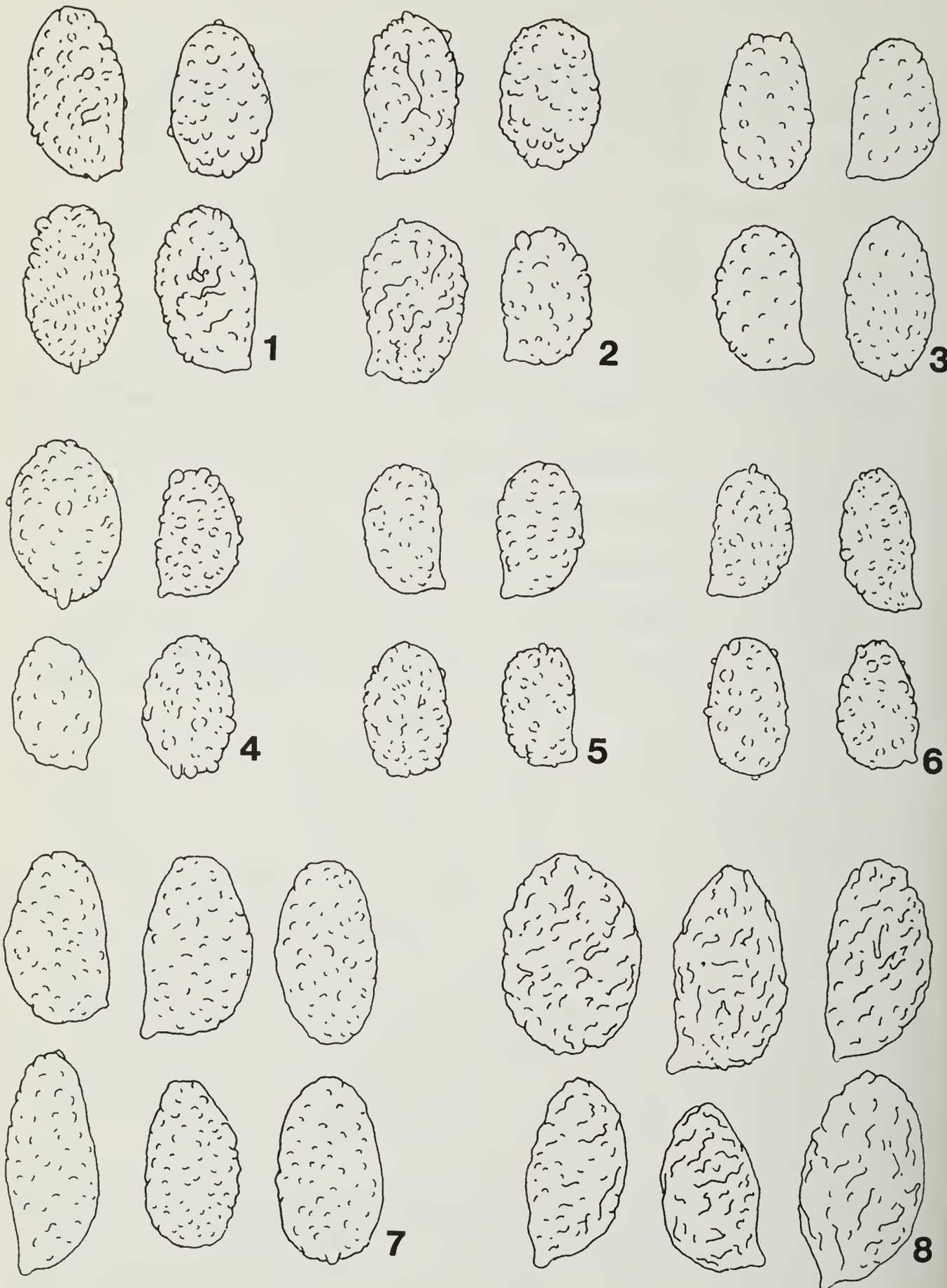
Dermocybes are among the most common fleshy fungi in Michigan during the fall mushroom season. They are usually associated with conifers, but a few species, including one of those described here, are associated with hardwoods. Specimens have been accumulated from several areas in Michigan over a number of years, and recently it has been possible to study material from the Huron Mountains in the Upper Peninsula.

The study of Michigan specimens has resulted in a better understanding of previously recorded species, including *C. croceofolius* Peck, *C. malicorius* Fries, *C. sanguineus* (Fries) Fries, *C. semisanguineus* (Fries) Gillet, *C. purpureus* (Fries) Maire, and *C. chrysolitus* Kauffman, and the circumscription of five new species with three new varieties. Also, *C. uliginosus* Berkeley was discovered at Ives Lake in the Huron Mountains during the fall of 1970; previously it had only been collected in the northwestern United States.

This paper contains the descriptions of eight new taxa and notes on *C. uliginosus*. Data are from specimens that were described when fresh, properly dried, and later studied microscopically. The color designations enclosed in quotation marks are from R. Ridgway, *Color Standards and Color Nomenclature* (Washington, D.C., 1912). A 2.5% aqueous solution of KOH was used for the macrochemical color reactions and the microscopic studies.

Cortinarius pellstonianus sp. nov. (Fig. 4).

Pileus 3-6 cm latus, obtusus demum late umbonatus, ad marginem incurvus vel decurvus, fibrillosus, siccus, triste cinnamomeus vel triste brunneolo-cinnamomeus; contextus luteolo-olivaceus; odor et sapor plus minusve pungentes. Lamellae confertae, pallide brunneolo-cinnamomeae demum valde ochracheae. Stipes 4-7 cm longus, 4-9 mm crassus, fibrillosus, pallide brunneolo-cinnamomeus demum valde ochraceus, deorsum contusus olivaceo-fuscus, intus luteolo-olivaceus demum olivaceo-brunneus. Sporae 7-8.5 (9) × (4) 4.5-5.5μ, ellipticae, verruculosae. Typus: *A. H. Smith 66395* (MICH); prope Pellston, Emmet Co., Sept. 30, 1962.



Spores from holotypes (X1280). Fig. 1. *Cortinarius huronensis;* Fig. 2. *Cortinarius huronensis* var. *olivaceus;* Fig. 3. *Cortinarius incognitus;* Fig. 4. *Cortinarius pellstonianus;* Fig. 5. *Cortinarius subcroceofolius;* Fig. 6. *Cortinarius subcroceofolius* var. *sordidipes;* Fig. 7. *Cortinarius tubarius;* Fig. 8. *Cortinarius tubarius* var. *luteofolius.*

Pileus 3-6 cm broad, obtuse expanding to broadly umbonate or nearly convex, margin incurved to decurved; surface appressed fibrillose, dry, color dark cinnamon to dull brownish cinnamon ("Vandyke brown" to "sayal brown"). Context yellowish (near "Isabella color"); odor and taste slight, ± pungent (not truly raphanoid); KOH rusty brown.

Lamellae adnexed, close, broad, color at first pale dull brownish cinnamon (a pale "sayal brown") becoming more ochraceous.

Stipe 4-7 cm long, 4-9 mm thick at the apex, enlarged downward; surface appressed fibrillose, ± concolorous with the lamellae, basal area olive-fuscous from handling; solid, within yellowish olive ("Isabella color") or slightly more olive-brown in base.

Spores: "ochraceous-tawny" in deposit; 7-8.5 (9) × (4) 4.5-5.5μ, verruculose, in profile inequilateral, in face view elliptic to ovate, in KOH single spores light brown. *Basidia:* 4-spored, (23) 26-32 × 6-8μ, clavate; in KOH hyaline to pale vinaceous or containing particles of red to purplish red pigment. *Pleurocystidia:* none seen. *Cheilocystidia:* 12-16 × 6-7μ, clavate to broadly clavate, in KOH hyaline to pale vinaceous. *Lamellar trama:* hyphae subparallel, in KOH hyaline to pale vinaceous. *Pileus cuticle:* hyphae interwoven, ± radially arranged, in KOH hyaline to pale brownish or containing a brownish purple to dull vinaceous cytoplasmic pigment. *Clamp connections:* present and of the normal type. *Interhyphal pigment deposits:* present among the hyphae of the pileus, lamellae and stipe, in KOH yellowish to reddish.

Gregarious under aspen, September. Emmet Co.: *A. H. Smith 66395* (type).

C. pellstonianus is distinguished by the brownish cinnamon pileus, lamellae, and stipe, and by its association with aspen.

Cortinarius subcroceofolius sp. nov. (Figs. 5 & 9).

Pileus 2-6 cm latus, obtuse conicus demum convexus vel plano-convexus, umbonatus vel subumbonatus, ad marginem incurvus vel decurvus, fibrillosus demum fibrilloso-squamulosus, siccus, luteus, luteolo-olivaceus, brunneolo-olivaceus vel ochraceo-brunneus, demum triste brunneolo-olivaceus, cinnamomeo-brunneus vel rufo-brunneus; contextus pallide luteolus demum sordide luteolus; odor et sapor pungentes (raphanini) vel indistincti. Lamellae confertae, croceae vel ferrugineo-aurantiacae demum profundior aurantiacae vel brunneolo-aurantiacae. Stipes 3-7 cm longus, 3-8 mm crassus, fibrillosus, luteus, deorsum mox aurantiacus, sursum brunneus vel olivaceus, intus concolor cum pagina, demum olivaceus vel brunneus. Cortina lutea. Sporae (6) 7-9.5 (11) × (4) 4.5-5 (5.5)μ, ellipticae, verruculosae. Typus: *J. F. Ammirati, Jr. 5310* (MICH); prope Big Bay Point, Marquette Co., September 16, 1970.

Pileus 2-6 cm broad, obtusely conic to convex or plano-convex, umbonate to subumbonate, margin incurved to decurved; surface appressed fibrillose to fibrillose-scaly, dry, not hygrophanous, color when young yellowish to yellowish olive ("sulphine yellow" to "old gold") overall, soon becoming brownish olive ("tawny-olive") to yellow-brown or ochraceous-brown ("buckthorn brown" to "ochraceous-tawny"), finally reddish brown

Fig. 9. *Cortinarius subcroceofolius,* X1 (*J. F. Ammirati 5310*).

Fig. 10. *Cortinarius incognitus,* X4/5 (*J. F. Ammirati 5325*).

("tawny") to ± cinnamon brown ("cinnamon-brown") or dark brownish olive ("Dresden brown"), some fibrillose-scales with a vinaceous brown (± "benzo brown") cast; KOH reddish. Context solid, firm, pale yellow ("barium yellow") or dingy yellow, in some watery olive over the lamellae; odor and taste raphanoid or not distinctive; KOH yellow or faintly yellowish brown.

Lamellae adnate to adnexed or ± depressed, close, ± 8 mm broad, slightly ventricose mature, edges uneven, color when young orange-yellow, saffron yellow or rusty orange (rusty "ochraceous-orange") becoming deeper orange ("xanthine orange" to "orange-rufous") or brownish orange when mature.

Stipe 3-7 cm long, apex 3-8 mm wide, equal to ± enlarged below or tapered at immediate base, stuffed becoming hollow; surface appressed fibrillose, color when fresh yellow ("pinard yellow," dull "lemon chrome," or "primuline yellow") from base to apex (in age apex sometimes fading to paler yellow), soon becoming orange to reddish brown ("tawny") from the base upward and darker brownish to sordid in age, base at first dull orange or rusty orange ("apricot orange" to "rufous") and becoming sordid reddish brown ("tawny") to brown or olive in age; no distinct zones or patches of fibrils over the surface; KOH on surface reddish fading to yellowish; at first pith pale yellow and cortex rich yellow ("empire yellow" tinted "lemon chrome"), in age olivaceous to brownish within, especially in the base, or cortex of lower stipe dull orange to rusty orange. *Cortina* yellow ("pinard yellow").

Spores: (6) 7-9.5 (11) × (4) 4.5-5 (5.5)μ, in profile inequilateral, in face view elliptic to ovate, verruculose, in KOH single spores light brown. *Basidia:* 4-spored, 21-26 × 6.2-7μ, clavate to ventricose, in KOH hyaline to pale yellow, some containing droplets and colorless refractive granules or particles and masses of reddish orange, orange or yellow pigment. *Pleurocystidia:* none seen. *Cheilocystidia:* none seen. *Lamellar trama:* hyphae subparallel, in KOH hyaline to yellowish, some containing refractive particles of yellowish to yellowish orange pigment. *Pileus cuticle:* hyphae interwoven, ± radially arranged, in KOH nearly hyaline, pale yellowish to pale brownish or containing a ± concentrated purplish to vinaceous cytoplasmic pigment. *Clamp connections:* present and of the normal type or some on the cuticular hyphae of the medallion type. *Interhyphal pigment deposits:* present as large deposits among the hyphae of the pileus, lamellae and stipe, in KOH yellow, orange or deep red.

Scattered to gregarious under conifers, sometimes in *Sphagnum,* late August to mid-October. Chippewa Co.: *A. H. Smith 38429.* Marquette Co.: *J. F. Ammirati 5310* (type), *5329, 5375, 5567.*

The color of the pileus and stipe, especially the orange to reddish brown color change on the lower stipe surface, combined with spore size separates *C. subcroceofolius* from other species with orange lamellae. In the past it has often been confused with *C. croceofolius* Peck.

Cortinarius subcroceofolius var. **sordidipes** var. nov. (Fig. 6).

A typo differt: Lamellae triste croceae vel pallide brunneolo-aurantiaceae demum profundior brunneolo-aurantiaceae. Stipes luteus, deorsum demum

olivaceus vel olivaceo-brunneus. Sporae 7-9.5 × 4-5μ, ellipticae, verruculosae. Typus: *J. F. Ammirati, Jr. 5456* (MICH); prope Mass, Ontonagon Co., Sept. 28, 1970.

Pileus 1.8-4.0 cm broad, obtusely conic to obtusely convex, umbonate, margin incurved then decurved; surface dry, opaque, appressed fibrillose to fibrillose scaly, color yellowish to yellowish olive ("sulphine yellow" to old gold") at first, becoming olive-brown ("tawny-olive"), fibrils and fibrillose scales often ± dull brown (a dull brownish "tawny" to "benzo brown"); KOH deep red. Context solid, firm, whitish yellow to pale yellow (± "barium yellow" to "straw yellow"), sordid in age; odor and taste raphanoid.

Lamellae adnate to ± adnexed or depressed, close, to 7 mm broad, slightly ventricose, edges uneven, color at first (in buttons) dull orange-yellow to light brownish orange (brownish "raw sienna"), becoming more brownish orange ("mars yellow" to "sudan brown") when mature, edges yellowish at first; KOH reddish.

Stipe 2-5 cm long, apex 3-7 mm wide, equal or ± tapered below; surface fibrillose, yellow ("strontian yellow," "wax yellow," a dull "lemon yellow" or a dull "lemon chrome"), apex often paler in age, lower stipe sordid olivaceous, brownish or dull "tawny" to rusty brown; within at first yellowish, ± concolorous with the pileus context, becoming olivaceous in age. *Cortina* yellow (concolorous with the stipe apex of young basidiocarps).

Spores: 7-9.5 × 4-5μ, in profile inequilateral, in face view elliptic to ovate, verruculose, in KOH single spores light brown. *Basidia:* 4-spored, 23-30 × 5.5-6.5μ, clavate, in KOH hyaline to yellowish, some containing droplets and refractive granules or particles and masses of yellow pigment. *Pleurocystidia:* none seen. *Cheilocystidia:* 12-17 × 7.5-9.5μ, broadly clavate to clavate, in KOH hyaline to yellowish. *Lamellar trama:* hyphae subparallel, in KOH hyaline to yellowish, some containing refractive particles of yellowish pigment. *Pileus cuticle:* hyphae interwoven, ± radially arranged, in KOH hyaline to pale brownish or containing a ± concentrated brownish vinaceous, vinaceous or purplish brown pigment. *Clamp connections:* present and of the normal type or some on the cuticular hyphae of the medallion type. *Interhyphal pigment deposits:* present as large deposits among the hyphae of the pileus, lamellae and stipe, in KOH yellow, yellow-brown or yellow-orange.

Scattered to gregarious under conifers, September and October. Ontonagon Co.: *J. F. Ammirati 5455, 5456* (type), *5457.*

Var. *sordidipes* differs from var. *subcroceofolius* by the dull or orange-yellow lamellae of young basidiocarps and the absence of the orange to rusty orange color on the lower stipe surface and cortex.

Cortinarius incognitus sp. nov. (Figs. 3 & 10).

Pileus 1.5-6 (8) cm latus, conicus vel convexus demum late convexus vel plano-umbonatus, ad marginem incurvus vel decurvus, fibrillosus vel fibrilloso-squamulosus, siccus, margine triste luteo vel luteolo-olivaceo, disco brunneo dein luteolo-brunneo, denique triste brunneo dein rufo-brunneo; contextus pallide luteus demum brunneolus; odor et sapor raphanini vel indistincti.

Lamellae confertae, luteae vel triste olivaceo-luteae demum ferrugineo-brunneae. Stipes 3-7 cm longus, 2-7 mm crassus, fibrillosus, luteus, deorsum demum olivaceus dein vinaceo-brunneus tum ferrugineo-brunneus, intus luteus demum olivaceus dein vinaceo-brunneus. Cortina lutea. Sporae 7-9.5 (10-11) × 4-5 (5.5-6)μ, ellipticae, verruculosae. Typus: *J. F. Ammirati, Jr. 1354* (MICH); prope Hell, Livingston Co., October 20, 1967.

Pileus 1.5-6 (8) cm broad, conic to convex becoming plano-convex to plane, umbonate to subumbonate, margin incurved to decurved, occasionally plane to uplifted; surface moist to dry, not hygrophanous, appressed fibrillose to squamulose, color at first dull yellow to yellowish olive ("antimony yellow," "yellow ocher," or "honey yellow") on the margin, brown to yellowish brown ("cinnamon-brown," "raw sienna," or "ochraceous-tawny") on the disc, becoming dull brown to reddish brown ("Prout's brown," "cinnamon-brown," or "chestnut" to "auburn") overall; KOH reddish to reddish brown. Context 2-5 mm thick at the disc, thinner over the lamellae, solid, firm to watery, color light yellow to light yellowish green ("primrose yellow," "Marguerite yellow") becoming watery and ± concolorous with the pileus surface; odor and taste not distinctive or raphanoid.

Lamellae sinuate to depressed or uncinate, seceding in age, close to crowded, up to 6 mm broad, moderately thick, lamellulae usually in three tiers, color at first yellow ("amber yellow" to "primuline yellow"), becoming dull olive-yellow ("aniline yellow") then rusty brown to rusty reddish brown ("raw sienna," "hazel," or "Sanford's brown"), often staining ± vinaceous brown to reddish brown in age; in KOH surface reddish.

Stipe 3-7 (10) cm long, 2-7 mm thick, equal or tapered downward, base slightly enlarged in some; surface appressed fibrillose, color at first yellow ("primuline yellow" to "wax yellow") overall, usually becoming olivaceous then vinaceous brown to dull reddish brown or rusty brown on the lower portion and base; stuffed becoming hollow, within at first yellow (± concolorous with the surface) becoming olivaceous then dull vinaceous to brownish vinaceous (especially in the lining of the cavity).

Spores: 7-9.5 (10-11) × 4-5 (5.5-6)μ, in profile inequilateral, in face view elliptic to ovate, verruculose, in KOH single spores light brown. *Basidia:* 4-spored, 23-31 × 7-8.5μ, clavate to broadly clavate, in KOH hyaline to pale vinaceous and containing droplets and colorless granules or particles of yellow, orange or red pigment. *Pleurocystidia:* none seen. *Cheilocystidia:* 12-23 × 6-11μ, clavate to broadly clavate, in KOH hyaline to pale vinaceous. *Lamellar trama:* hyphae subparallel, in KOH hyaline, yellow or reddish and some containing particles and masses of yellow to red pigment. *Pileus cuticle:* hyphae interwoven, ± radially arranged, in KOH nearly hyaline to pale brownish or containing a ± concentrated reddish brown to vinaceous cytoplasmic pigment. *Clamp connections:* present and of the normal type. *Interhyphal pigment deposits:* common as large deposits among the hyphae of the pileus, lamellae and stipe, in KOH yellow, orange or red.

Scattered to gregarious in conifer woods, often in sandy pine or pine-hardwood areas, usually September to November, less frequently from

May to September. Livingston Co.: *J. F. Ammirati 1354* (type), *1383, 1519.* Marquette Co.: *J. F. Ammirati 5325, 5391.* Washtenaw Co.: *J. F. Ammirati 2682.*

C. incognitus is the most common yellow-gilled *Dermocybe* in Michigan. Its habitat, color, and spore size make it distinctive. It may be confused with *C. huronensis* but can be easily separated by spore size.

Cortinarius huronensis sp. nov. (Fig. 1).

Pileus 2-4 cm latus, convexus dein plano-convexus demum planus, umbonatus, fibrillosus demum fibrilloso-squamulosus, humidus vel siccus, margine olivaceo dein luteolo-olivaceo, disco olivaceo dein luteolo-olivaceo vel bruneolo, demum fusco-brunneo, contextus pallide luteus demum olivaceus; odor et sapor raphanini. Lamellae confertae, luteae dein brunneolo-luteae tum ferrugineo-brunneae. Stipes 6.5-7.5 cm longus, 3-6 mm crassus, fibrillosus, luteus vel viridi-luteus, basi aurantiaco vel olivaceo, interdum rufo-brunneus vel triste aurantiacus fibrillosus, deorsum demum triste luteus, intus luteus demum olivaceus. Sporae 8.5-11 (12) × (4.5) 5-6.2μ, ellipticae, rugosae vel verruculosae. Typus: *J. F. Ammirati, Jr. 5403* (MICH); prope Canyon Lake in Huron Mountain Club, Marquette Co., September 23, 1970.

Pileus 2-4 cm broad, convex to plano-convex or plane, umbonate, some ± depressed around the disc, margin fibrillose to fibrillose-scaly, moist to dry, not hygrophanous, color at first olivaceous ("old gold") to yellowish olive on the margin and similarily colored or more brownish on the disc, soon becoming brown ("buckthorn brown") to ochraceous-brown ("ochraceous-tawny") with an olivaceous tint overall, more brownish in age, often becoming streaked dull brown ("snuff brown") to deep brown ("bister"), old pilei sometimes fuscous-brown overall; KOH reddish to reddish brown. Context solid, firm to watery, pale yellow ("barium yellow") becoming watery olive, especially over the lamellae; odor and taste raphanoid.

Lamellae adnate to sinuate or emarginate, seceding in age, close, to 7 mm broad, ± ventricose at maturity, edges uneven, color at first yellow ("wax yellow" to "primuline yellow") becoming brownish yellow, finally rusty brownish yellow, edges pale yellowish.

Stipe 6.5-7.5 cm long, 3-6 mm thick, equal or slightly clavate; surface appressed fibrillose, color at first yellow ("amber yellow") to greenish yellow ("citron yellow") becoming duller yellow below, some of the surface fibrils on the lower stipe usually tinted dull reddish brown ("tawny") to dull orange (dull "apricot orange") and becoming more brownish to olivaceous in age, base olivaceous and often tinted dull orange; stuffed then hollowed, cortex yellow ("primuline yellow" to "wax yellow") at first, becoming olivaceous to dark olive especially below, pith dull yellow then olivaceous, cavity dull reddish brown to vinaceous brown ("natal brown") in age.

Spores: 8.5-11 (12) × (4.5) 5-6.2μ, in profile inequilateral, in face view elliptic to ovate, rugose to verruculose, in KOH single spores light brown. *Basidia:* 4-spored, clavate, (20) 25-31 × 7-9.2μ, in KOH hyaline to faintly yellow, some containing droplets and colorless granules or particles of yellow to yellow-green pigment. *Pleurocystidia:* none seen. *Cheilocystidia:* 10-18 ×

6-11μ broadly clavate to clavate, in KOH hyaline to yellowish. *Lamellar trama:* hyphae subparallel, in KOH hyaline or containing a ± pale yellow cytoplasmic pigment or particles of yellow pigment. *Pileus cuticle:* hyphae interwoven, ± radially arranged, in KOH nearly hyaline to pale brown or containing a ± concentrated reddish brown, brownish orange or brown cytoplasmic pigment. *Clamp connections:* present and of the normal type. *Interhyphal pigment deposits:* present as large deposits among the hyphae of the pileus, lamellae and stipe, in KOH yellow, orange or reddish to reddish brown or fuscous-olive to fuscous-brown in the subcuticular zone of the pileus.

Scattered to gregarious in *Sphagnum* and other mosses or in moist humus under conifers, September to November. Marquette Co.: *J. F. Ammirati, Jr. 5402, 5403* (type), *5404, 5638.*

C. huronensis most frequently grows in conifer-*Sphagnum* bogs. Its larger spores and color separate it from *C. incognitus,* and the reddish KOH reaction of the pileus surface easily distinguishes it from *C. tubarius. C. chrysolitus* Kauffman differs mainly by its light greenish lamellae.

Cortinarius huronensis var. **olivaceus** var. nov. (Figs. 2 & 11).

A typo differt: Pileus sordide cinnamomeus vel olivaceo-brunneus; contextus isabellinus. Lamellae triste isabellinae demum ferrugineo-brunneae. Stipes sordide luteo-bubalinus, basis ochraceus, sparse olivaceo-brunneo-fibrillosus. Typus: *A. H. Smith 64679* (MICH); Mud Lake Bog, Washtenaw Co., October 14, 1961.

Pileus 2-4 cm broad, obtusely campanulate becoming nearly plane with an obtuse umbo; surface dry, fibrillose-streaked, dull brown ("sayal brown") to olive-brown ("tawny-olive") on a light dull yellowish buff ("colonial buff") ground color, in age more olive-brown ("tawny-olive") overall; KOH red to reddish brown. Context dull yellowish buff ("deep colonial buff") or more watery olivaceous; odor ± raphanoid, taste raphanoid or not distinctive.

Lamellae adnexed, close, broad, edges even, color at first dull yellowish buff ("deep colonial buff") to dull olive-yellow or ocher yellow ("olive-ocher" to "yellowish ocher"), slowly more rusty brown; KOH reddish on the surface.

Stipe 4-9 cm long, 6-10 mm thick, equal or nearly so; surface fibrillose, color dull yellowish buff ("deep colonial buff") from apex to base but overlaid, except at apex, by a thin coating of olive-brownish to "tawny-olive" fibrils causing it to appear duller, stipe base ochraceous and not discoloring.

Spores: 8.5-10.5 (11.5) × 5-6μ, in profile inequilateral, in face view elliptic to ovate, rugose to verruculose, in KOH single spores yellowish brown. *Basidia:* 4-spored, 25-34 × 6.5-8.5μ, narrowly clavate to clavate or ± ventricose, in KOH hyaline to pinkish or containing particles of red to reddish purple pigment. *Pleurocystidia:* none seen. *Cheilocystidia:* 13-15 × 7-8μ, broadly clavate to clavate, in KOH hyaline to pinkish. *Lamellar trama:* hyphae subparallel, in KOH hyaline to pale reddish or containing particles of red to purplish red pigment. *Pileus cuticle:* hyphae interwoven, ± radially arranged, in KOH hyaline to pale vinaceous, brownish or yellowish brown, some encrusted. *Clamp connections:* present and of the normal type or some on the pileus

cuticular hyphae of the medallion type. *Interhyphal pigment deposits:* present as large deposits among the hyphae of the pileus, lamellae and stipe, in KOH red to purplish red.

Gregarious in *Sphagnum* under conifers, October. Washtenaw Co.: *A. H. Smith 44008, 44009, 44010, 44011, 44019, 64679* (type).

The dull yellowish buff to olivaceous colors of the young basidiocarps make this variety distinct from var. *huronensis.* The pilei often become more brownish as they mature and may be ochraceous brown to cinnamon brown in age.

Cortinarius tubarius sp. nov. (Figs. 7 & 12).

Pileus 2-5 cm latus, obtuse campanulatus demum planus vel plano-umbonatus, siccus, subisabellinus demum olivaceo-brunneus; contextus olivaceus. Lamellae confertae demum subdistantes, pallide luteoli-viridulae demum olivaceo-brunneae dein fulvae. Stipes 6-14 cm longus, 6-12 mm crassus, fibrillosus, pileo concolor, deorsum demum olivaceo-brunneus, intus olivaceus demum olivaceo-brunneus. Sporae 9.2-11.5 × 5-6μ, ellipticae, rugosae vel verruculosae. Typus: *A. H. Smith 64673* (MICH); Mud Lake Bog, Washtenaw Co., October 14, 1961.

Pileus 2-5 cm broad, obtusely campanulate becoming plane or plano-umbonate; surface dry, appressed fibrillose, margin lacerate in age and in some sulcate-striate, color dull yellowish olive (near "Isabella color") when young, becoming dull olive-brown ("tawny-olive") or duller; KOH olive-fuscous. Context olivaceous (± "Isabella color"); KOH olive.

Lamellae adnexed, broad, close to subdistant, color at first dull light yellowish green ("reed yellow") to dull yellowish olive ("Isabella color") becoming a dingier dark yellow-brown to dull fulvous; KOH reddish or olive-brown on older lamellae.

Stipe 6-14 cm long, 6-12 mm thick, equal; surface appressed fibrillose, apex concolorous with young lamellae, general color dull yellow and not overlaid by a distinctly colored layer of fibrils, in age between dull yellowish olive ("Isabella color") and dull olive-brown ("tawny-olive") lower down. Context ± concolorous with pileus context, darkening to olive-brown in base.

Spores: 9.2-11.5 × 5-6μ, in profile inequilateral, in face view elliptic to ovate, rugose to verruculose, in KOH single spores pale brownish. *Basidia:* 4-spored, 27-34 × 6.5-8.5μ, clavate, in KOH hyaline and often containing refractive hyaline to yellowish granules and droplets. *Pleurocystidia:* none seen. *Cheilocystidia:* none seen. *Lamellar trama:* hyphae subparallel, in KOH hyaline or faintly colored. *Pileus cuticle:* hyphae interwoven, ± radially arranged, in KOH hyaline to pale yellowish or yellowish brown, slightly encrusted. *Clamp connections:* present and of the normal type. *Interhyphal pigment deposits* common as large deposits among the hyphae of the pileus, lamellae and stipe, in KOH yellow, yellowish brown, brownish orange or slightly more orange to reddish.

Gregarious in *Sphagnum* under conifers, September to November. Washtenaw Co.: *A. H. Smith 33-1008, 18884, 64673* (type).

Fig. 11. *Cortinarius huronensis* var. *olivaceus*, X1 (*A. H. Smith 64679*).

Fig. 12. *Cortinarius tubarius* var. *tubarius*, X1 (*A. H. Smith 64673*).

C. tubarius var. *tubarius* differs from *C. tubarius* var. *luteofolius* by its light greenish yellow lamellae and dull yellowish stipe. It differs from *C. huronensis* var. *olivaceus* by the olive-fuscous KOH reaction of the pileus surface of fresh basidiocarps and the absence of brownish olive universal veil fibrils on the stipe.

Cortinarius tubarius var. **luteofolius** var. nov. (Fig. 8).

A typo differt: Lamellae luteae vel luteolo-olivaceae demum brunneae. Stipes luteus ad apicem, deorsum luteolo-olivaceus vel brunneus demum ferrugineo-brunneus. Typus: *J. F. Ammirati, Jr. 5055* (MICH); prope Ives Lake, Marquette Co., August 27, 1970.

Pileus 2.5-4.5 cm broad, at first obtusely conic to campanulate, expanding to plano-convex or plane, umbonate, margin incurved then decurved; surface appressed fibrillose to fibrillose-scaly, becoming ± rimose, color at first olivaceous ("old gold") becoming brownish olive then brownish ("buckthorn brown") to reddish brown (a brownish "tawny"); KOH fuscous brown. Context pale dull yellow ("amber yellow") to watery dull yellowish; odor and taste raphanoid.

Lamellae depressed to subdecurrent, seceding in age, close, to 7 mm broad, edges uneven, color at first yellow ("wax yellow") then yellowish olive (yellowish "old gold"), finally brownish ("buckthorn brown"), slight yellowish tone usually noticeable; KOH reddish brown on surface.

Stipe 6.5-11 cm long, apex 4-8 mm thick, base slightly clavate, 6.5-12 mm thick; surface appressed fibrillose, apex yellow ("barium yellow" to "amber yellow"), below yellow-olive to the base; base tomentose, whitish yellow to yellowish olive, in age base darker olive and surface discoloring brownish to rusty brown above; stuffed becoming hollow, within at first concolorous with the surface, becoming brownish to sordid, especially in the cavity, in the base olivaceous. Cortina yellowish, thin.

Spores 9-11 (12) × 4.5-6 (6.5)μ, in profile inequilateral, in face view elliptic to ovate, rugose to verruculose, in KOH single spores light brownish. *Basidia:* 4-spored, 28-36 × 8-9μ, clavate, in KOH hyaline, often containing droplets or refractive yellowish to colorless granules. *Pleurocystidia:* none seen. *Cheilocystidia:* 14-23 × 4-10μ, clavate to narrowly clavate, in KOH hyaline. *Lamellar trama:* hyphae subparallel, in KOH hyaline to faintly colored. *Pileus cuticle:* hyphae interwoven, ± radially arranged, in KOH hyaline, pale yellowish or pale yellowish brown. *Clamp connections:* present and of the normal type. *Interhyphal pigment deposits:* present as large deposits among the hyphae of the pileus, lamellae and stipe, in KOH yellowish olive, yellowish brown to fuscous or tinted reddish to orange.

Gregarious in *Sphagnum* under conifers, late August to mid-October. Marquette Co.: *J. F. Ammirati 5055* (type), *5200, 5580.*

C. tubarius var. *luteofolius* often occurs with *C. tubarius* var. *tubarius* and *C. huronensis* var. *huronensis.* It is separated from the former by the yellow lamellae of young specimens and the more yellow stipe. From the latter it is more easily distinguished by the fuscous-brown KOH reaction of the pileus surface of fresh basidiocarps.

Cortinarius uliginosus Berkeley, Outlines of British Fungeology, pp. 190-191. 1860.

Pileus 1.5-4.5 cm broad, at first conic to campanulate becoming more obtuse to convex or finally plane, with a rounded to slight umbo, margin ± incurved; surface dry, not hygrophanous, appressed fibrillose becoming ± fibrillose-scaly, some pilei ± rimose, color reddish orange ("English red") on the margin, disc ± concolorous with the margin or duller orange ("burnt sienna") to deep orange-red ("mahogany red"), edge of the margin may be paler orange to yellowish orange, in age often darker ("mahogany red" to "bay") overall; KOH deep red to reddish vinaceous. Context solid or ± hollowed at the stipe apex, color pale yellow ("barium yellow" to "straw yellow") or paler yellow, ± dingy in age, often with a watery olivaceous zone over the lamellae; odor and taste raphanoid; KOH brownish yellow.

Lamellae adnate to sinuate, seceding, close, to 8 mm broad, not ventricose, moderately thick, edges even, color dull yellow ("aniline yellow" to "yellow ocher") to brownish yellow (a yellowish "buckthorn brown"), finally ± "ochraceous-tawny," edges usually remaining pale yellowish, in age some streaked or spotted orange to reddish orange.

Stipe 3.5-6 cm long, apex 2-8 mm thick, equal or slightly enlarged downward; surface fibrillose, covered from near the apex to the base by a coating of reddish orange (a light "grenadine red," a reddish "bittersweet orange" or "grenadine") universal veil fibrils, ground color (at apex and where fibrils are thinner) pale yellow ("straw yellow" to pale "baryta yellow") becoming sordid in age or tinted with color of the veil, veil fibrils often duller in age; stuffed becoming hollow, within concolorous with pileus context or paler, sordid to brownish in age, base ± brownish olive in age, cortex of young stipes often tinted yellow-orange to orange. Cortina pale yellowish.

Spores: 8.5-11 (14) × 5.5-6.2 (7)μ, in profile inequilateral, in face view elliptic to ovate, verruculose, in KOH single spores brownish.

Scattered to gregarious or cespitose in moist or marshy areas under *Salix* and *Alnus,* July to October. Marquette Co.: *J. F. Ammirati 5269, 5297, 5393, 5401.*

C. uliginosus is easily recognized by its overall color, large spores and occurrence with *Salix* and *Alnus* in damp or marshy areas. It is considered a rare species, the cited collections representing the first from Michigan.

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ADDITIONAL NOMENCLATURAL AND OTHER NOTES ON MICHIGAN MONOCOTS AND GYMNOSPERMS

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In previous papers I have called attention (1966) to the necessity of using different names for several of our monocots from those employed in current manuals; and (1967) to the status of certain species reported erroneously, or in suspected error, from the State. In the meantime, some additional notes have accumulated, chiefly in regard to names which require clarification for nomenclatural (as opposed to taxonomic) reasons. Now that the first part (covering gymnosperms and monocots) of the Michigan Flora is in press, this last opportunity is taken for more complete explication of certain points than would be appropriate in the Flora; for a continuing compilation of instances when reasons other than taxonomic judgment would require application of what may be an unfamiliar name to some taxa; for explaining failure to follow certain nomenclatural changes proposed in recent literature; and for discussion of some spurious geographic records.

Pinus banksiana Lambert

It has recently been asserted emphatically by Argus (Canad. Jour. Bot. 49: 573-576. 1971) that the nomenclaturally correct name for jack pine is *Pinus divaricata* (Aiton) Dumont. I cannot accept this conclusion. This binomial is based on *P. sylvestris* δ *divaricata* Aiton (Hort. Kew. 3: 366. 1789). I agree with Argus that this name, in infraspecific rank, is validly published. The brief description ["foliis divaricatis obliquis"] and geographic statement ["Hudson's Bay Pine Tree"] could refer only to jack pine. Argus and, before him, Boivin (Phytologia 15: 154. 1967) have concluded that Dumont de Courset (Bot. Cult. 3: 760. 1802) raised the epithet to specific rank the year before Lambert published the name *Pinus banksiana.* However, an examination of Dumont's work makes very clear that *P. divaricata* was not validly published as a binomial in 1802. Under Scots pine, Dumont recognizes several varieties (p. 760 is headed "Variétés"), the third one of which is the pin "à feuilles divergentes. *P. divaricata* H. K." Little (Check List of Trees, 261. 1953) referred to this as a "*nom. subnud.*" but this is irrelevant. No description whatsoever is required for a new combination, and if this binomial were to be accepted, it is clearly based on Aiton's infraspecific epithet ["H. K." = Hortus Kewensis, as explained by Dumont in his list of abbreviations, 1: 276-278].

The important point is neither of the arguments against *P. divaricata* quoted and rejected by Argus (p. 574). Art. 34 of the International Code of Botanical Nomenclature states that a name "is not validly published when it is not accepted by the author." Dumont does not accept *P. divaricata* as a species to which a binomial applies; he considers jack pine to be a variety of

Scots pine, exactly as Aiton had done. He gives French common names as his primary nomenclatural entries, citing one or more Latin names when available (none at all for varieties 4 and 5 of Pin sauvage, Pin d'Ecosse, or Pin de Genève—the Scots pine). Why he cited "*P. divaricata*" as if it were a binomial (and similarly *P. maritima*) and did not cite trinomials for his varieties in this instance, as he did in many others, is not clear. Dumont (1: 31-32) does have a very definite idea of the ranks of species and variety, and he definitely treated jack pine as a variety of Scots pine.

It could be argued furthermore that "*P. divaricata*" as a binomial was published by Dumont in synonymy, which would also invalidate the name under Art. 34; but it is not necessary to develop this argument in addition to his unquestioned failure to accept *P. divaricata.*

In view of the nomenclatural incorrectness of the name *P. divaricata,* I hope that it does not become widely accepted and used in botanical and forestry literature through failure to understand the actual circumstances under which the name was invalidly published.

Potamogeton capillaceus Poiret

After study of plants from the Southeast, Klekowski and Beal (Brittonia 17: 175-181. 1965) considered *P. capillaceus* not to be distinct from *P. diversifolius* Raf. Michigan plants of this Coastal Plain species are known from several small lakes in Allegan and Newaygo counties, and appear sufficiently distinct that I tentatively retain them under the familiar name—at least until the type of *P. capillaceus* can be examined in order to be certain of its application. In October, 1970, I searched extensively for Poiret's material of *P. capillaceus* in the herbarium of the Muséum National d'Histoire Naturelle in Paris, with the generous help of Dr. A. Lourteig and M. Claude Sastre, but no such material could be located. Poiret indicated that he had seen specimens "in herb. Desfont." and the type, if it exists, may therefore have gone with Desfontaines' general herbarium to the Istituto Botanico, Firenze. (Likewise, no type for *P. nodosus* Poiret could be found at Paris. It may be at Montpellier, with the Broussonet herbarium—a possibility not considered by Ogden [Rhodora 45: 131. 1943].)

Poideae: Poeae

The alternative name for the Gramineae is Poaceae, and the type of both family names is therefore the genus *Poa* (Art. 18, Note 3, International Code of Botanical Nomenclature). The subfamily which includes that genus must therefore be called Poideae, and the tribe which includes the genus must be called Poeae (Art. 19). Recent works by authorities on grasses, such as Gould's *Grass Systematics* (McGraw-Hill, 1968) and Pohl's "The Grasses of Iowa" (Iowa St. Jour. Sci. 40: 341-566. 1966), continue to place *Poa* in a tribe Festuceae and a subfamily Festucoideae. These latter names are legitimate only if used for taxa which include *Festuca* but not *Poa.* If *Festuca* is included in the same tribe and subfamily as *Poa,* the names of the higher ranks must be based on the stem of the type genus, *Poa.*

Bromus ciliatus L.

Baum (1967, p. 1849) would typify this name by a Linnaean specimen at Stockholm, previously identified by Hitchcock as *B. latiglumis.* Hitchcock (1908, p. 122) pointed out that this specimen and a similar one in the Linnaean Herbarium (London) are in fact *B. latiglumis* and are so at variance with Linnaeus' unusually ample description of *B. ciliatus* that they should not be taken as types of that name. Linnaeus apparently erred either in numbering this material "4" to correspond with *B. ciliatus* in the Species Plantarum or in writing his description of this species. I am inclined to accept Hitchcock's judgment that the former must be the case and that there is consequently no type specimen for *B. ciliatus.* In the absence of more precise data such as dates or collection numbers, I think we are not obligated to conclude that Linnaeus' notation on the Stockholm specimen, indicating that it was grown at Uppsala from Canadian seed supplied by Kalm, necessarily designates a holotype as asserted by Baum. Linnaeus doubtless grew many plants from seed, and the discrepancy between these specimens and the original description suggests that they were incorrectly labeled as *B. ciliatus.* (See comments on Linnaean typification under *Panicum latifolium,* below.) Having applied *B. ciliatus* to what has been called *B. latiglumis* or, following Wagnon, *B. purgans,* Baum would use the name *B. canadensis* Michaux for what has long been called *B. ciliatus.*

Bromus kalmii Gray

Baum (1967, pp. 1848-1849) points out that the type of this name is the same as the type of *B. purgans* L., and the latter name should thus supplant the former. However, *B. purgans* was long applied to what we should now call *B. pubescens*; and it was applied by Wagnon to what had long been called *B. latiglumis* (see Voss, 1966, p. 440). To employ the name *B. purgans* now in a third sense would be highly undesirable; to avoid confusion and ambiguity, the name may be rejected under Art. 69 of the Code.

Bromus latiglumis (Shear) Hitchcock

If *B. purgans* is rejected under Art. 69 or is applied to *B. kalmii* (see above), then the available name for this plant is the long-familiar *B. latiglumis* (unless one accepts Baum's contention that *B. ciliatus* should be typified by a specimen of this species [see above]).

Calamagrostis stricta (Timm) Koeler

As pointed out with full references by Löve (Taxon 19: 299-300. 1970), this name should be used for what has been called *C. neglecta* (Ehrh.) Gaertner, Meyer, & Scherbius. The latter name is based on *Arundo neglecta* Ehrhart (Beitr. Naturk. 6: 137. 1791), which is illegitimate since *Arundo halleri* Willd. is listed in synonymy. *C. neglecta* is therefore, under Art. 72 of the Code, to be treated as new by Gaertner, Meyer, & Scherbius (Fl. Wetterau 1: 94. 1799)[1] rather than itself illegitimate (as termed by Löve). It is typified

[1]Page numbers 93 and 94 are repeated in this flora. *C. neglecta* is published on the *first* p. 94.

by the only material cited: "*Arundo neglecta* Ehrh." The latter name is to be typified, according to Art. 7, "by the type of the name or epithet which ought to have been adopted under the rules, unless the author of the superfluous name or epithet has indicated a definite type." If *Arundo neglecta* Ehrh. is typified by the cited synonym which he "ought to have adopted," *A. halleri* Willd. (Fl. Berol. Prodr. 60. 1787), the name becomes ultimately based on *Agrostis calamagrostis* L. (Syst. ed. 10, 2: 872. 1759)–a grass now classified in the genus *Stipa* or the segregate *Achnatherum,* of which it is the type. [Willdenow required a new epithet in the genus *Arundo* to avoid creation of a homonym of *Arundo calamagrostis* L. (Sp. Pl. 1: 82. 1753), which is the type of the genus *Calamagrostis.*] This line of argument would require that *Calamagrostis neglecta* Gaertner, Meyer, & Scherbius be listed in the synonymy of *Stipa calamagrostis* (L.) Wahl. or *Achnatherum calamagrostis* (L.) Beauv.

An alternative argument seems to me preferable, based on the position that Ehrhart "indicated a definite type" by citation of his own exsiccata no. 118 (also listed, from Upsala, on p. 84). This is *C. neglecta* as long understood. The inclusion of *Arundo halleri* Willd., while rendering Ehrhart's name superfluous under Art. 63, would then be considered the result of a misinterpretation (as indeed it was). This typification of Ehrhart's name would allow *C. neglecta* (1799) to be listed as a taxonomic synonym of *C. stricta* (Timm) Koeler, based on *Arundo stricta* Timm (1795). Koeler (Descr. Gram. 105. 1802) cited both Timm [whose work I have not seen] and Ehrhart, as well as Gaertner, Meyer, and Scherbius, so there is no doubt that in his mind all of these authors were dealing with the same plant.

Festuca tenuifolia Sibthorp

F. capillata Lamarck (Fl. Franç. 3: 597. 1778) is an illegitimate name, superfluous when published (Art. 63) because of the citation of *F. amethystina* L. in synonymy. The next available name for this plant, when recognized as a species distinct from *F. ovina,* is apparently *F. tenuifolia* Sibth. (Fl. Oxon. 44. 1794)–as listed in the "Punt Report" (Preliminary Report on the Stabilization of Names of Plants of Economic Importance. Regnum Vegetabile 36. 1964).

Koeleria macrantha (Ledeb.) Schultes

In my previous nomenclatural report (1966, p. 441), I followed Shinners' error in citing Sprengel as author of the above combination. Greuter (Candollea 23: 85. 1968) confirms that this is the correct binomial for what had formerly been called *K. cristata,* and gives the correct author of the combination as Schultes.

Lolium perenne var. *aristatum* Willd.

This name was validated by reference to Vaillant [Bot. Paris. 1727] p. 80, t. 17, f. 3. Vaillant's brief Latin name, including the phrase "spica aristis donatum," combined with his figure, leaves no doubt that he was dealing with the ryegrass often now known as *L. multiflorum* Lam. Willdenow's

varietal name is validly published, despite the claim of Terrell (Tech. Bull. U.S. Dep. Agr. 1392: 9, 49. 1968) that it must be rejected under Rec. 32A. (The Recommendation is a guide for current practice, not a rule prohibiting any validation by reference to pre-Linnaean literature.) If the ryegrass sometimes given specific recognition as *L. multiflorum* Lam. is treated as a variety of *L. perenne,* then var. *aristatum* Willd. (Sp. Pl. ed. 4, 1: 462. 1797 '*aristata*') antedates other varietal epithets (e.g., *multiflorum, italicum*) the correct citation of which is, furthermore, a considerable nomenclatural tangle.

Panicum latifolium L.

Baum (1967) has proposed shifting the application of a number of grass names on the grounds that Hitchcock's typification of them was in violation of the present Code of Nomenclature. The names in question had been typified by Hitchcock (1908) on the basis of Kalm specimens in the Linnaean Herbarium. Baum holds that if Linnaeus did not specifically cite Kalm in the protologue of a name, the Kalm material is ineligible for consideration in lectotypification whenever some other reference is cited by Linnaeus. There seems to be little doubt that the return of Kalm from North America in June of 1751 was a major incentive to Linnaeus to prepare the final draft of the Species Plantarum (see Stearn, 1957, p. 72) and that Kalm's specimens were before him as he wrote (Stearn, p. 107). The "Guide for the Determination of Types" in the Code states that a lectotype "must be chosen from among elements that were definitely studied by the author up to the time the name of the taxon was published and included in the protologue." I am assured by a number of colleagues more experienced in nomenclature than I, and from both sides of the Atlantic, that it would be entirely too arbitrary to exclude Kalm's specimens from consideration as lectotypes if they were available to Linnaeus before 1753–even if Kalm does not happen to be cited in the Species Plantarum for a given species. Stearn (pp. 125-126) points out clearly that "all the constituent elements in Linnaeus' protologue must be taken into consideration. The most important of these is the phrase-name. . . ." Linnaeus "would never have chosen an element disagreeing with the phrase-name to typify his species." When a Kalm specimen closely agreeing with the phrase-name or description has (often for that very reason) been selected as lectotype, it is unjustifiable to abandon such lectotypification in favor of another element. As Stearn states (p. 130) in regard to species based on several elements, a lectotype "must be selected to control application of the name, as far as possible in accordance with the presumed intent of the author and preferably in accordance with subsequent and current usage. In choosing this lectotype, special attention should be given to the history and source of the Linnaean phrase-name. . . . The specimen now present under a particular name in the Linnaean Herbarium may have no relevance to the original publication of that name. Hence each entry should be critically analyzed and care be taken to avoid any hasty disturbance of current usage."

Hitchcock (1908, p. 118), after critical analysis, designated as lectotype of *Panicum latifolium* a Kalm specimen to which the description applies well,

and there is no need to upset the traditional usage of the name. Baum would call our plant *P. macrocarpon* LeConte, applying *P. latifolium* to what has been called *P. boscii* Poiret.

Phragmites australis (Cav.) Steudel

The first name, under the rules of nomenclature, for the common reed is *Arundo phragmites* L. (1753), but the tautonym rule forbids transfer of the epithet to the genus *Phragmites.* The first legitimate name in the latter genus has long been thought to be *P. communis* Trin. (1820), based on *A. phragmites* L. However, the taxonomic synonym *Arundo australis* Cav. (1799) is considerably earlier and hence the correct name for the plant is *Phragmites australis* (Cav.) Trin. ex Steudel (1841), as has been carefully explained by Greuter and Rechinger (Boissiera 13: 174. 1967) and Clayton (Taxon 17: 168-169. 1968).

Sorghastrum nutans (L.) Nash

Baum (1967, p. 1850) disagrees with the designation by Hitchcock (1908, p. 125) of a Kalm specimen in the Linnaean Herbarium as the type of *Andropogon nutans,* the basionym of *S. nutans.* However, since the Kalm specimen was surely studied by Linnaeus before 1753 and agrees with his phrase-name, it would be an unjustified procedure, leading to instability in nomenclature, to reject Hitchcock's selection of it as lectotype. To rule it out because Linnaeus did not explicitly refer to Kalm in the protologue is to adopt too narrow a procedure for typification of Linnaean species (see under *Panicum latifolium,* above).

Bulbostylis capillaris (L.) Clarke

The distribution map for this species recently published by Kral (Sida 4: 212. 1971) has a dot in Emmet County, Michigan—far north of any other known stations in the State. The record proves to be erroneous, as revealed by a bit of sleuthing and the kind assistance of Dr. Kral. The basis for the record is a specimen of *Rhynchospora capillacea* in the herbarium of Ohio State University, collected by C. F. Wheeler in 1879 and correctly identified. It is mounted on a sheet with three other collections, including one of *Bulbostylis* from Hubbardston [Ionia Co.], which is not mapped by Kral. Obviously data from the wrong specimen were recorded for mapping purposes. I still know of no records of *Bulbostylis* in Michigan north of Newaygo and Montcalm counties, although the superficially similar *Fimbristylis autumnalis* (L.) R. & S. is known north, very locally, to Emmet and Cheboygan counties (not mapped north of Newaygo County by Kral, p. 216).

Carex: Carex

When observing that many of the names often treated as sectional in rank in *Carex* have not been validly published in that rank, or have not been so published by the author to whom they are usually ascribed, I earlier (1966, p. 451) accepted too readily the statement of Mackenzie (N. Am. Fl. 18: 10. 1931) and others that the type of the generic name is *C. acuta* L. Prompted

by a query on the matter from Dr. Carroll E. Wood, I have investigated further and conclude that the type of the genus is *C. hirta* L.; hence the section which includes this species must be called *Carex* and not *Hirtae.* (The section which includes *C. acuta,* then, may continue as *Acutae.*) If the group names are recognized as convenient assemblages, not in the formal rank of section, the same usage may be employed in the spirit of the Code.

Mackenzie in Britton and Brown (Ill. Fl. ed 2, 1: 352. 1913) first gave the type of the genus as *C. pulicaris* L. This designation is surprising, for Mackenzie recognized the two main groups "Vignea" and "Eu-Carex," although not identifying these as subgenera (or sections). *C. pulicaris* does not belong in *Eucarex. Eucarex* (as a section)[2] dates from Cosson and Germain (Fl. Paris ed. 2, 744. 1861),[3] who thus in effect excluded species not in *Eucarex* from the options for lectotypification of the genus. Noting this, Green in Hitchcock and Green (Internatl. Bot. Congr. Cambridge 1930, Nomencl. Prop. Brit. Bot. 187. 1929) selected *C. hirta* L. as the type. Two years later, Mackenzie named *C. acuta* as the type.

In the absence of a specific rule stating that the lectotype of a genus must be selected from among those species retained in a previously segregated typical section or subgenus, common sense would certainly demand this procedure.[4] The alternative, in the present instance, would be to accept *C. pulicaris* as the type, requiring that the subgenus containing it be called *Carex* (rather than *Primocarex*) and that the group known since 1886 (subgenus) and 1861 (section) as *Eucarex* (under current rules to be called *Carex*) receive a different name. *C. hirta* and its allies are included in section *Carex,* placed in subgenus *Carex,* by Clapham, Tutin, and Warburg (Fl. Brit. Is. ed 2. 1962) but by few if any other recent floras.

So far as I am aware, no one has commented in print on the discrepancies between the measurements given for *Carex* in Gleason's *New Britton and Brown Illustrated Flora* (1952) and the scale of magnification indicated in the figures. In the first two species illustrated, for example, the perigynium of *C. nardina* at 28 mm is shown "X6" which would make it over 4.5 mm long in nature, and the perigynium of *C. praegracilis* at 30 mm is also shown "X6" which would make it 5 mm long. But the text gives the length as 3-3.5 mm and 3-4 mm, respectively, for the perigynia of these species. Similar irregularities exist throughout the genus. Having recently had an opportunity to examine the original drawings from which these illustrations were made, I can offer an explanation. Excluding *Carex,* the original drawings for the

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[2]Often erroneously attributed to Cosson and Germain as a subgenus. Bailey, who brought considerable order to the nomenclature of subdivisions of this genus, was apparently the first to treat *Eucarex* as a subgenus (Proc. Am. Acad. 22: 60. 1886), based on Cosson and Germain's sectional name. Kükenthal (Bot. Jahrb. 27: 519 et passim. 1899) followed Bailey's lead in recognizing subgenus *Eucarex.*

[3]Often erroneously cited as 1845, the first edition.

[4]Vuilleumier and Wood (Jour. Arnold Arb. 50: 272. 1969) have applied similar reasoning in *Cacalia,* lectotypifying it by one of the species retained by DeCandolle in *Eucacalia.*

Illustrated Flora were made twice the intended size and reduced one-half in printing. The *Carex* figures, however, were cut out of the larger drawings done by Creutzburg for Mackenzie's two-volume *North American Cariceae* (1940).[5] The original Creutzburg drawings showed the habit figures natural size; the plates were reduced to 2/3 of their size for printing. The fragments of them were also reduced to 2/3 for the Illustrated Flora, but the scales of magnification indicated by Gleason were apparently based on the assumption that the drawings had been reduced one-half, like the drawings of all other genera in that Flora. Most habit figures in *Carex,* therefore, in the Illustrated Flora are actually X2/3 when said to be X1/2, and the figures of details are similarly about a third larger than indicated. The figure of *C. stipata* (p. 312) is X2/3 although no scale is given.

Fimbristylis puberula (Michaux) Vahl

This name is adopted by Kral (Sida 4: 133. 1971), who assigns to var. *puberula* the plants from this region variously recognized in the past as *F. caroliniana* (Lam.) Fern. [by Gleason & Cronquist], *F. drummondii* (Torrey & Hooker) Boeckl. [by Fernald], or *F. spadicea* (L.) Vahl [by Svenson in N. Am. Fl.].

Scleria lindleyana Clarke ?

In the University of Michigan Herbarium is a mysterious sheet of *Scleria,* purporting to have been collected in Michigan in 1838. The collection consists of four fruiting culms, which appear to be *S. lindleyana,* a species known only from South America according to Core (Brittonia 2: 15. 1936). *S. hirtella* Sw., a similar species which ranges into the southern United States, might be a more reasonable expectation if this is an authentic North American collection, but the achenes (about 1.5 mm long, a bit large for *S. lindleyana*) have 12 deep pits or pores at the base, unlike *S. hirtella.* Basal parts are lacking, so that it is impossible to ascertain whether the plants are annual (as in *S. lindleyana*) or perennial (as in *S. hirtella*). The achenes are perfectly smooth beyond the basal pores and the foliage and scales of the spikelet are pubescent. The plants have the aspect of a very robust *S. verticillata,* which they resemble in inflorescence and in the absence of a basal disc on the achenes.

This collection was labeled as *Scleria triglomerata* Michx. in the land of Mrs. J. H. Ehlers (*ca.* 1920-1930), and was subsequently annotated as "Not" this by E. L. Core. In 1951, P. A. Hyypio determined it as *S. lindleyana.* The "original" label is a pencilled one in the hand of an assumed herbarium assistant ca. 1870-1880, as pictured by McVaugh (Mich. Bot. 9: 221, fig. 5. 1970) in discussing similarly labeled collections from the First Geological Survey of Michigan. The date is July 28, 1838–consistent with other First Survey collections for the locality: "Kalamazoo (Small Lakes)." The original

[5] In this work, Mackenzie stated that the figures "showing habit were 2/3 natural size; the magnification of details varies." No further scales were given for the details; measurements were supplied only in the descriptions.

identification, however, is "Juncus acumunatus," the epithet being crossed out and replaced by "effusus," perhaps in the same hand. The sheet came from the herbarium of Miss E. C. Allmendinger (cf. Mich. Bot. 9: 219. 1970). I have seen no First Survey collections of any species of Juncus from Kalamazoo County, of which this label might have been intended to represent a duplicate. There is a First Survey collection of *Scleria triglomerata* labeled by John Wright, collected at Grand Prairie July 23, 1838. This species looks quite different at a glance, however, and the specimens in question, with simple verticillate inflorescence, also do not resemble any *Juncus.* The circumstantial evidence that the label does not belong with the specimen is so strong that admission of *S. lindleyana* to the authentic flora of Michigan appears unjustified.

Scirpus pendulus Muhl.

Schuyler (Not. Nat. 390. 1966) has made clear that the name *Scirpus lineatus* Michaux actually applies to the species of the Southeast formerly known as *S. fontinalis* Harper. The correct name for the sedge previously known in our region as *S. lineatus* then becomes *S. pendulus.*

Xyris difformis Chapman

This name is applied by Kral (Sida 2: 251. 1966) to what has been called *X. caroliniana* Walter in most recent manuals. The latter name applies to what previously had been widely known as *X. flexuosa* (Sida 2: 235. 1966).

Juncus dudleyi Wiegand

This species appears distinct in the local flora, but is sometimes treated as a variety of *J. tenuis* Willd. (e.g., Vasc. Pl. Pac. Northw. 1: 209. 1969). Unfortunately, when so treated the correct name appears to be *J. tenuis* var. *uniflorus* (Farw.) Farw. (Am. Midl. Nat. 9: 265. 1929), based on *J. interior* var. *uniflorus* Farw. (Rep. Mich. Acad. 20: 169. 1919). The type (*Farwell 4533½,* in herbarium of Cranbrook Institute of Science) has coriaceous auricles and is *J. dudleyi.* In varietal rank, Farwell's epithet antedates var. *dudleyi* (Wieg.) Hermann (Journ. Arnold Arb. 25: 56. 1944.) The type of Farwell's var. *billingtonii,* published at the same time, is a depauperate fragment without distinct auricles and I am unwilling to assign it taxonomically.

Lilium lancifolium Thunberg

A thorough discussion of the reasons for applying this name to the tiger lily, rather than the later *L. tigrinum* Ker, has been given by Ingram (Baileya 16: 14-19. 1968).

Trillium grandiflorum (Michaux) Salisb.

Leafless plants of this species were named *T. chandleri* by Farwell (Rep. Mich. Acad. 20: 158. 1919), who also named no less than six forms in this "species." Recognizing the trivial nature of the variations in *T. grandiflorum,*

Victorin (Contr. Inst. Bot. Univ. Montréal 14: 30. 1929) transferred Farwell's specific epithet to formal rank and it appears thus in Gray's Manual: *T. grandiflorum* f. *chandleri* (Farw.) Vict. However, Victorin's transfer created an illegitimate name under Art. 60 of the Code; for he should have based a combination with *T. grandiflorum* on the oldest name in the rank of form—i.e., any of Farwell's six named forms of the same date.

Sisyrinchium angustifolium Miller

As clarified by Ward (Taxon 17: 273-274. 1968) and treated in Gray's Manual, this is the plant long known as *S. graminoides* Bickn. [as in Gleason & Cronquist] or more recently as *S. bermudiana* L. sensu Shinners (Rhodora 59: 702. 1957). Most early records of *S. angustifolium* from Michigan are referable to what should be called *S. montanum* Greene (including *S. angustifolium* sensu Alexander in Gleason & Cronquist).

Habenaria blephariglottis × *H. ciliaris*

The binomial *H.* ×*schweinfurthii* Luer (Am. Orchid Soc. Bull. 37: 324. 1968) is not validly published; the correct binomial for this hybrid is *H.* ×*bicolor* (Raf.) Beckner (Am. Orchid Soc. Bull. 37: 480-482. 1968).

Listera smallii Wiegand

Correll (Nat. Orchids N. A. 127. 1950) states that there is a sheet of this Appalachian twayblade in the University of Michigan Herbarium "said to have been collected by a Mr. Shoop at Rock Harbor, Isle Royale, Michigan." He admitted that this "is a questionable record." In the University Herbarium is a sheet, annotated by Correll as *L. smallii* in 1946, clearly labeled "Smoky Mts N Carolina Side." It was collected by Rev. D. R. Shoop and was originally identified as *L. convallarioides*. There is also a sheet bearing two collections: one of *L. convallarioides* from Rock Harbor, without collector or date, and the other labeled by Miss E. C. Allmendinger merely with "Listera convallarioides *Orch.* Mr. Shoop." Even though the Isle Royale specimen is on a separate small sheet of paper with its own label, strapped to the larger sheet which bears the specimens of *L. smallii,* the specimens were apparently all assumed by Correll, who annotated them in 1946, to be from Isle Royale. The Shoop specimens, although lacking locality, are quite probably part of the more amply labeled North Carolina collection.[6]

[6]Rev. Darius R. Shoop, apparently an enthusiastic amateur botanist, exchanged specimens with Miss Elizabeth Allmendinger beginning in 1867. In 1868, he moved to Bellevue, Eaton County, Michigan, and subsequently he lived in Manchester and St. Louis, Michigan, before accepting a call to the Presbyterian Church of Hastings at the end of 1878. He seems to have traveled a good deal and collected in a number of states. Apart from the fact that he was married and had a child, little further information about him can be gleaned from the several letters (1867-1878) which he wrote to Miss Allmendinger and which are filed with her correspondence in the University of Michigan Herbarium.

ORCHIDS OF ISLE ROYALE

Fortunately, *Listera smallii* (discussed above) is not included in Johnsson's account of the orchids of Isle Royale (Wolf's Eye 6(2). 1963), distributed by the Isle Royale Natural History Association. In view of the interest in the orchids of Isle Royale, however, it might be well to clarify certain other records (some briefly noted in Mich. Bot. 3: 102. 1964).

Habenaria leucophaea, the prairie fringed orchid, is listed by Johnsson as "very rare on Isle Royale . . . blooms normally in July, but on Isle Royale it can probably be found well into August." Inclusion of this authentic-sounding information apparently results from no recent collections but only from an early report repeated by Brown (Ferns & Flowering Plants of Isle Royale, Michigan. Natl. Park Serv. [1937]). The basis of this report is a collection by A. E. Foote, July 17, 1868, which has been determined by Fuller in 1931 and by Correll in 1946 as *H. psycodes,* an identification in which F. W. Case concurs. If the flowers were light-colored, as suggested by Foote's original identification as *H. leucophaea,* perhaps this was one of the occasional albinos of *H. psycodes.*

Goodyera pubescens, the downy rattlesnake-plantain, is not known from any Isle Royale collections. Brown's material from Tonkin Bay has been referred by Correll to *G. tesselata,* and older collections from Isle Royale said to be *G. pubescens* were likewise misidentified.

Liparis liliifolia, the lily-leaved twayblade, was included by Brown (whose listings were evidently accepted by Johnsson) on the basis of an old report by Holt. No specimens have been found, and the species is otherwise not known in Michigan north of Saginaw County nor in northern Wisconsin. It is extremely unlikely that it occurs on Isle Royale.

Spiranthes cernua, nodding ladies-tresses, on the other hand, is an addition to Johnsson's list of the orchid flora of Isle Royale. A specimen collected in 1901 by Stuntz and Allen is in the herbarium of the University of Wisconsin.

The net result of these additions and subtractions is a list of 32 species of orchids known authentically from Isle Royale. All except *Calopogon* are mapped by Case (Orchids Western Great Lakes Region. 1964). The native Michigan orchid most likely yet to be discovered there is *Habenaria lacera,* the ragged fringed orchid. Others, however, might turn up, including *Aplectrum hyemale, Goodyera pubescens,* the introduced *Epipactis helleborine*—and perhaps some of the more boreal species known in Ontario, such as *Malaxis paludosa* (on the Sibley Peninsula opposite Isle Royale).

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Review

WILD FLOWERS OF OHIO AND ADJACENT STATES. By Isabelle H. Klein. Published for the Cleveland Museum of Natural History by The Press of Case Western Reserve University, Cleveland. 1970. n. p. $5.95.

Here is an attractive, truly pocket-sized book with 809 species illustrated by small but quite adequate line drawings. The brief descriptions and statements of habitat are always conveniently on the page facing the figures. Almost never is there any geographical information on distribution in Ohio (or elsewhere); *Potentilla anserina* and *Hypericum kalmianum* are cited for the Lake Erie shore, but *Cakile edentula* and *Euphorbia polygonifolia,* which are similarly restricted, are not so described. The text is preceded by 8 excellent color plates showing 23 diverse species (not concentrated on the "showy" flowers) appearing "posed" on a black background. There are no cross references to the color figures in the text or index. The book (said in advertising to have 204 pages) completely omits page numbers, although each species bears a consecutive number (used in the index).

Shrubs as well as herbaceous plants are included, but no trees. Omitted are "extremely rare" species (though not *Plantago cordata*) and those "in genera where identification is extremely difficult." Thus, there are no pondweeds, grasses, sedges, or hawthorns. Often there is a notion that other species of a genus are found in Ohio. But it is not clear what criterion led to complete omission of some species which might justifiably have been mentioned, such as *Iris cristata, Cannabis sativa, Cicuta bulbifera.*

The sequence of families and the scientific names follow Gray's Manual, and the author is to be commended for not wasting space citing names of authors (which would only have been copied out of the manual). The sequence of species within a family is apparently random, and the species of a genus are not always even adjacent (423, 432). There is an illustrated chart for identification of some families, but this is poorly correlated with the text: numerous families are omitted (e.g., Loranthaceae, Aizoaceae, Callitrichaceae, Haloragidaceae); the names Papaveroideae, Fumariaceae [misspelled, as are two other family names], and Nelumbonaceae, used in the chart, are nowhere mentioned in either text or index. There has been an inconsistent and rather loose effort to avoid technical terminology. "Stem" is used to cover both petiole and pedicel, leading to such technical errors as stating that the stems of *Nuphar variegatum* are "flattened, often margined"; yet "petiole" is used for *Lycopus americanus* and "pedicel" for *Oxalis europaea.* A spadix is defined as a kind of flower, and there are a few other careless lapses and typographical errors. The Bibliography omits Weishaupt's "Vascular Plants of Ohio"—a set of keys which would nicely complement this keyless but illustrated guide.

Altogether, this appears to be a useful, compact field guide for which Ohioans can be grateful. Even omitting the numerous species merely mentioned and not illustrated, the price averages less than three-fourths of a cent per species, which is very reasonable coverage in these days of inflated book prices!

—E. G. V.

TIPULARIA DISCOLOR IN SOUTHWESTERN MICHIGAN

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On September 19, 1970, I found a colony of the crane-fly orchid, *Tipularia discolor* (Pursh) Nutt., in Berrien County, Michigan. At least 200 plants were growing in leaf mold in a deciduous woods on the north side of Bridgman.

This species has previously been known to range north to southern Indiana and Kentucky, and west to northeastern Ohio (reported from Cuyahoga and Medina counties by Correll, 1950; mapped from Geauga and Lorain counties by Case, 1964). Old reports from Michigan have never been authenticated. Specimens from Berrien County have now been deposited in the herbarium of The University of Michigan.

This is one of the "winter-leaf" orchids, like Calypso and Putty-root (*Aplectrum*). Leaves in the Bridgman colony were still present in late May, 1971, but by the second week of June there were none evident.

Fred W. Case informed me that in August of 1970 Victor Soukup of Cincinnati had notified him of the discovery of *Tipularia* near Grand Mere (Stevensville), several miles north of Bridgman and also in Berrien County. There were three fertile plants at the Grand Mere station, in an area of blowdown of trees resulting from the opening of the woods during construction of I-94. Subsequent dense growth of spicebush may have shaded out these plants, as nothing was in evidence on August 1, 1971, whereas on the same day there were 17 plants in bloom when Soukup and I visited the Bridgman station.

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VERTICAL DISTRIBUTION OF THE LICHEN GENUS *PHYSCIA* ON BIGTOOTH ASPEN, NORTHERN RED OAK, AND RED MAPLE AT DOUGLAS LAKE, MICHIGAN

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Patterns in the vertical distribution and directional aspect of the species of *Physcia* were investigated on trunks of *Populus grandidentata* (bigtooth aspen), *Quercus rubra* (northern red oak), and *Acer rubrum* (red maple). Previously studies of a similar type, mostly unpublished, were made by Schwerer (1962), Garren (1963), Hinds (1968), and Jones (1969).

The present study was carried out in sections 26 and 27 of Munro Township in Cheboygan County, in the vicinity of Douglas Lake, northern Michigan. The aspens were chosen from a dense aspen stand containing occasional red oaks and red amples. The red maples were selected from an open forest comprised largely of red maples and red oaks. The red oaks represented scattered individuals in a mixed aspen-red oak forest. Each sample consisted of 10 trees selected by a random pairs method. Trees were limited to those between 14 and 16 meters in height and were climbed by a ladder when no limbs were present to provide a handhold. As each tree was climbed, it was marked into two-meter bands. Within each band a cylindrical quadrat 10 centimeters in height was located by means of random numbers. Quadrats were placed only as high as 12 meters on the bole. All species of *Physcia* were recorded as to height and occurrence on the north or south sides of the trees. Specimens of the *P. stellaris-P. aipolia* group were brought back to the laboratory for precise identification. (*P. aipolia* is usually almost identical to *P. stellaris* except for white spots on its upper cortex and some features of the rhizines. These characters are not diagnostically reliable, however, and a color test with KOH must be applied.) All the other species are easily recognized in the field.

If the rank of "stand" is assigned to a single tree, the term "constancy" can be used to indicate the number of times a species occurs at a given height throughout the sample. The constancy on each species of tree was determined for the three most common species (Fig. 1). A total of seven species of *Physcia* occurred in the quadrats. Relative frequency and actual number of occurrences for all species are presented in Table 1. The species with the greatest number of occurrences are *P. stellaris, P. adscendens,* and *P. aipolia,* in that order. The other species were much less common in occurrence: *P. millegrana,* eight times; *P. orbicularis,* seven; *P. pulverulenta,* two; and *P. ciliata,* one. (The last two are not included in the discussion because of insufficient data.)

The distribution of *P. stellaris* is as follows: On aspen the highest constancy is reached in the vicinity of 10 meters. On red oak it is at approximately four meters and on red maple at six meters. A significant

overlap in the vertical distribution of *P. stellaris* is evidenced on red oaks and red maples, as shown in Figure 1. The distribution of *P. aipolia* differs from that of *P. stellaris* in that it has its greatest occurrence lower on all three species of tree, with peaks at no more than six meters (Fig. 1). *P. stellaris* shows a preference for higher levels on aspen but no important differences in preference on oak or maple. *P. adscendens* has a broad distribution on aspen with a slight peak at two meters and a relatively high constancy up to eight meters. On red maples *P. adscendens* peaks abruptly at two meters and is not present after eight meters. Only three specimens of *P. adscendens* were found on red oak, but they occurred at two-, four-, and eight-meter levels, suggesting a broad vertical distribution (Fig. 1).

Schwerer (1962) reported that *P. aipolia* is highly directional in aspect. Her sample consisted of nine specimens from six aspens. Our larger sample of 36 specimens from 10 aspens indicates that the difference between the distribution on the north and south sides of the trees is less than 6% at any level, with the south side having two more specimens than the north. A

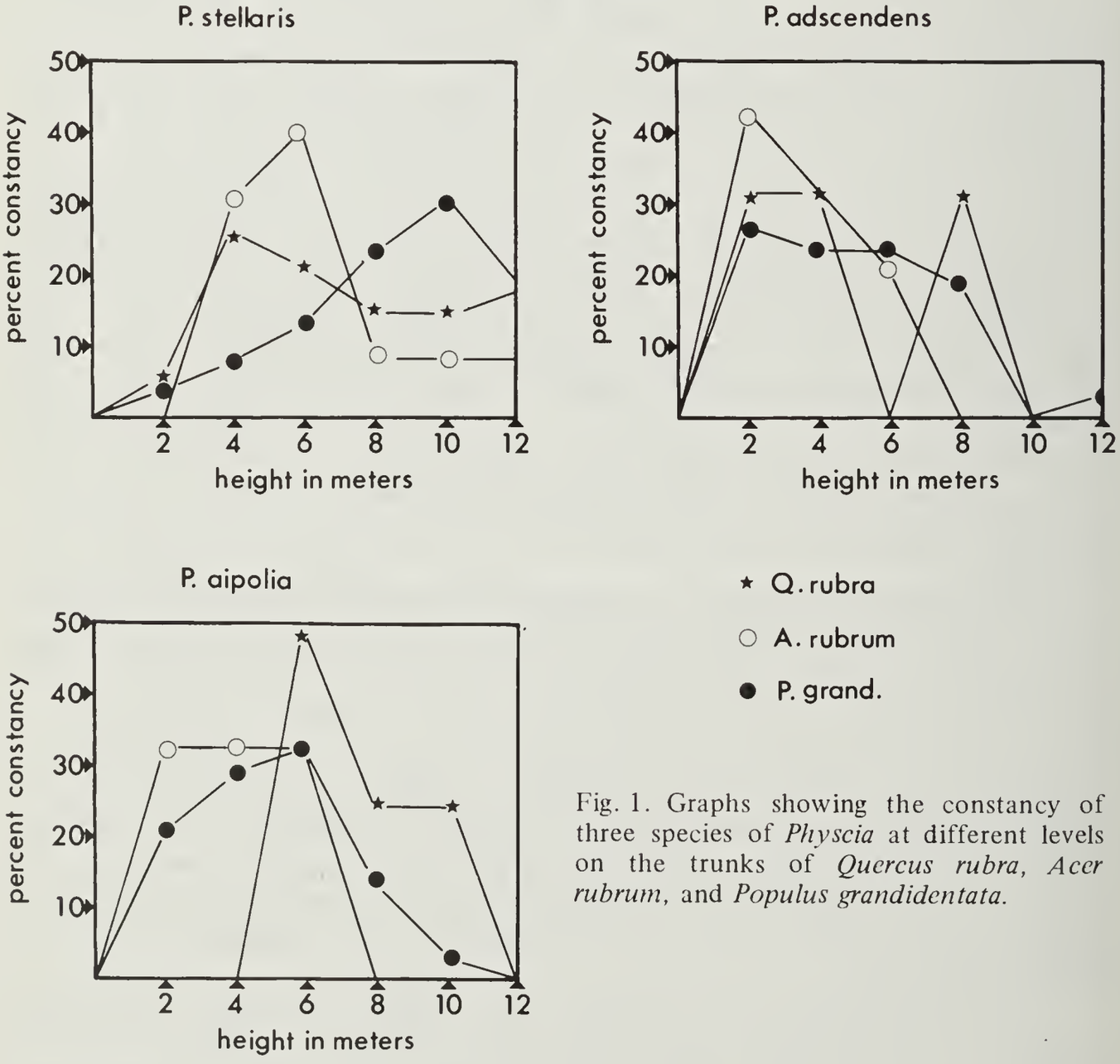

Fig. 1. Graphs showing the constancy of three species of *Physcia* at different levels on the trunks of *Quercus rubra*, *Acer rubrum*, and *Populus grandidentata*.

TABLE 1. Summary of relative frequency and aspect occurrence of species of *Physcia* on bigtooth aspen, northern red oak, and red maple.

	Total Occurrence	Relative Frequency	Aspect	
			North	South
P. stellaris	60	40%	43	42
P. aipolia	31	21%	19	24
P. adscendens	41	27%	22	23
P. orbicularis	7	5%	4	6
P. millegrana	8	5%	3	4
P. ciliata	1	less than 1%	1	0
P. pulverulenta	2	1%	0	2

similar pattern on aspen is shown by *P. adscendens. P. stellaris* also illustrates a lack of substantial difference between the north and south aspects, that difference being less than 8% (Table 1).

Vertical distribution of the several species of *Physcia* follows patterns, as clearly shown by our data and also suggested in earlier studies by Garren (1963), Hinds (1968), Jones (1969), and Schwerer (1962). The reasons for the patterns and why they differ according to species of tree are difficult to assess. Some factors that could be correlated with vertical distribution are bark pH and water-holding capacity, nutrient leaching by stem flow, light intensity, and rate of evaporation, all varying at different levels. Hale (1967) suggested that bark pH may have a primary effect on germination of spores of lichen fungi and on growth of free-living algae suitable for lichenization. Bark porosity, hardness, and water-holding capacity are related to evaporation rate. Hale found that the order of magnitude of the rate of evaporation from different species of hardwoods is not sufficient to explain differences in lichen communities. Light gradients and humidity gradients would seem to be important factors affecting vertical distribution. Certain correlations can be made with vertical distribution, but the lack of a gradual transition from one species to another from the base upward and the presence of some species along the entire length of the trunk indicate that none of these factors is likely to be the sole influencing agent.

It has been demonstrated, especially by Garren's work on windthrown trees in Minnesota, that on *Populus grandidentata, Physcia aipolia* is more typically found at lower levels, whereas *P. stellaris* is more abundant upward. This would seem to provide a biological basis for recognizing two species which differ more in chemistry than in structure. It is an interesting result of our study, based on a larger and more random sample, that such a difference does indeed exist on *Populus,* but not on other trees under investigation. *Populus* is a pioneer in the succession leading toward the local hardwood climax, and *Physcia stellaris* plays a pioneering role on that tree, showing a distinct preference for the younger, more exposed, upper levels. It is surprising to find that on red maple, equally a pioneer species, it favors older, more protected, lower levels, as it does also on red oak which may be somewhat

higher in the successional series and presumably offering somewhat more shade and greater humidity. We do not have the physical measurements to show what the differences are at various levels on different trees, but it appears that there is no correlation with the changes in light intensity and humidity associated with succession. It is true that *Physcia aipolia* shows a preference for lower levels in all the trees investigated, and this has some chemotaxonomic significance, but unless other bark factors can be correlated with vertical distributions, the support for chemotaxonomy supposedly provided by vertical distributions alone must be de-emphasized.

ACKNOWLEDGMENTS

We would like to thank Howard Crum and Edwin Phillips for their assistance throughout this project.

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Jones, R. E. 1969. Vertical distribution of Physcia stellaris (L.) Nyl. and Physcia aipolia (Ehrh.) Hampe on bigtooth aspen and northern red oak in the vicinity of Douglas Lake, Michigan. Unpublished report, University of Michigan Biological Station.

Schwerer, Glenda S. 1962. Aspect and vertical distribution of lichen species on Populus grandidentata. Unpublished report, University of Michigan Biological Station.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan botany under four categories: A. Maps, Soils, Geology, Climate (new maps and selected bulletins or articles on matters useful to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan—not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (institutions as well as travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

—E. G. V.

A. MAPS, SOILS, GEOLOGY, CLIMATE

The following topographic maps for Michigan have been published by the U.S. Geological Survey, 1200 S. Eads St., Arlington, Virginia 22202, since the previous listing in our January 1971 issue. All are 7½-minute quadrangles (scale of 1:24,000 or about 2½ inches to a mile). Maps are supplied with green overprint showing wooded areas unless request is made to the contrary, and are $.50 each, with a 20% discount on orders totalling $20.00 or more. Revised maps are marked with an asterisk in the list below; others are new or resurveyed. Following the name of the quadrangle, the county or counties in which it primarily lies are added.

Adair* [St. Clair]
Algonac* [St. Clair + Ontario]
Allenton* [St. Clair]
Armada* [Macomb]
Battle Run* [St. Clair]
Belle Isle* [Wayne + Ontario]
Betsy Lake North [Luce]
Betsy Lake NW [Luce]
Betsy Lake South [Luce]
Betsy Lake SW [Luce]
Birmingham* [Oakland]
Brighton [Livingston]
Butman [Roscommon, Gladwin]
Byron [Genesee, Shiawassee, Livingston]
Clarkston* [Oakland]
Davisburg [Wayne]
Dearborn* [Wayne]
Detroit* [Wayne + Ontario]
Goodells* [St. Clair]
Grosse Pointe* [Wayne]
Hadley* [Lapeer, Genesee]
Hale [Iosco]
Hartland [Livingston]
Highland* [Oakland]
Highland Park* [Wayne, Macomb]
Howell [Livingston]
Inkster* [Wayne]
Kent Lake [Livingston, Oakland]
Marine City* [St. Clair + Ontario]
Memphis* [St. Clair]
Meredith NW [Roscommon, Clare]
Meredith SW [Clare]
Metamora* [Lapeer]
Milford* [Oakland]
Mt. Clemens East* [Macomb]
Mt. Clemens West* [Macomb]
Muskellunge Lake East [Luce]
Muskellunge Lake West [Luce]
Muskellunge Lake SW [Luce]
Muskellunge Lake SE [Luce]
New Baltimore* [St. Clair]
New Haven* [Macomb]
Oak Grove [Livingston]
Omer [Arenac]
Omer SW [Arenac]
Ortonville* [Oakland]
Oxford* [Oakland]
Pontiac North* [Oakland]
Pontiac South* [Oakland]
Port Huron* [St. Clair + Ontario]
Prescott [Ogemaw, Arenac]
Richmond* [Macomb]
Rochester* [Oakland]
Romeo* [Macomb]
Royal Oak* [Oakland, Wayne]
Skidway Lake [Ogemaw, Arenac]
Smiths Creek* [St. Clair]
Sterling [Arenac]
Sterling SW [Arenac, Gladwin]
Utica*[Macomb]
Waldenburg* [Macomb]
Warren* [Macomb, Oakland]
West Highland [Oakland, Livingston]
Whittemore [Iosco, Arenac]

Limited revisions of the following sheets in the 1:250,000 series (at $.75 each) have been issued: Manitowoc (NL-16-11), Marquette (NL-16-5), and Tawas City (NL-17-10).

Bazin, M., & G. W. Saunders, 1971. The hypolimnetic oxygen deficit as an index of eutrophication in Douglas Lake, Michigan. Mich. Academ. 3(4): 91-106. [Includes speculations on the effects of deforestation, reforestation, and other factors in the long term natural eutrophication of this well studied lake.]

Haney, James E. 1971. Michigan Geology Deducing What the Glaciers Did. Research News, Off. Res. Adm., Univ. Mich. 22(4). 11 pp. [Includes 8 clear maps showing stages in the history of the Great Lakes, together with brief text.]

Hendrickson, G. E., & C. J. Doonan. 1971. Reconnaissance of the Sturgeon River, a Cold-Water River in the Northcentral Part of Michigan's Southern Peninsula. U.S. Geol. Surv. Hydrol. Invest. Atlas HA 353. 2 sheets. [Data on the river from its source near Gaylord to its mouth near Indian River, including depth, width, bed material,

bank material and height, bank vegetation, streamflow, water quality, and cultural features. 2 large folded sheets in a pocket. $1.25. (Note: HA 333 deals with the Pigeon River, HA 354 with the [Upper] Black River, and HA 384 with the Pere Marquette River, presumably in a similar fashion, but these have not been available for examination.)]

Hughes, John D. 1971. Post Duluth stage outlet from the Lake Superior basin. Mich. Academ. 3(4):71-77. [Locates post-Valders spillways across the Marquette and Munising moraines.]

Ozoga, John J. 1968. Variations in microclimate in a conifer swamp deeryard in northern Michigan. Jour. Wildl. Managem. 32: 574-585. [Considerable data presented for *Thuja* swamp in Alger Co.]

Tabbert, Russell (editor). 1970. Isle Royale Journal: 1. 32 pp. [This first number of a journal to be published two or three times a year is devoted to an analysis of "Isle Royale and the Wilderness Act." Nos. 2 (34 pp.) and 3 (15 pp.), issued in 1971, deal with various topics related to Isle Royale. Copies of No. 1 ($.75), 2 (1.00), and 3 ($.50) are available from their editor at 12375 East Portage Road, Portage, Ohio 53451.]

Van Den Brink, C., N. D. Strommen, & A. L. Kenworthy. 1971. Growing Degree Days in Michigan. Mich. Agr. Exp. Sta. Res. Rep. 131. 48 pp. [Graphs present average seasonal growing-degree-day accumulation and freeze probabilities for 41 stations distributed throughout the State. Summary maps include one showing average length of 32°F. freeze-free period.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Dore, William G. 1969. Wild-Rice. Canada Dep. Agr. Publ. 1393. 84 pp. $2.00. [A thorough treatment of the genus *Zizania,* its morphology, taxonomy (2 species in this area), habitat, production and use, natural enemies, and other aspects of its biology, including distribution of the taxa in Canada. An interesting old (1866) report from Drummond Island is cited but it is erroneously stated that "no subsequent collections have been made"; there is also reference to "one" stand in Cheboygan County which "probably" still exists (several stands do indeed still exist!).]

Fitting, James E. 1970. The Archaeology of Michigan. Natural History Press, Garden City. 274 pp. $18.95. [Includes information on crops and native plants in the economy of native peoples, as well as a useful radiocarbon chronology. See review in Mich. Bot. 10: 62. 1971.]

Little, Elbert L., Jr. 1971. Atlas of United States Trees Volume 1. Conifers and Important Hardwoods. U.S. Dep. Agr. Misc. Publ. 1146. 14 pp. + "200" maps + 9 overlays. $16.75. [Includes detailed distribution maps for all our native species of conifers. See review in Mich. Bot. 10: 207. 1971.]

Smith, Alexander H., & Harry D. Thiers. 1971. The Boletes of Michigan. Univ. Mich. Press, Ann Arbor. 428 + [14] pp. + 157 pl. $20.00. [A complete treatment, with keys, descriptions, and copious illustrations. See review in Mich. Bot. 10: 93. 1971.]

Westover, Alton J. [1971] The Use of a Hemlock-Hardwood Winter Yard by White-Tailed Deer in Northern Michigan. Occ. Pap. Huron Mt. Wildl. Found. 1. 59 pp. [Includes data on cover and available browse on plots in the Huron Mountains.]

C. JOURNAL ARTICLES

Bailey, Virginia L., Shirley B. Herlin, & Harold E. Bailey. 1970. Ptelea trifoliata ssp. trifoliata (Rutaceae) in deciduous forest regions of eastern North America. Brittonia 22: 346-358. [Some of the material analyzed morphologically and by thin-layer chromatography was from beech-maple woods on Lake Michigan dunes in the southwestern Lower Peninsula.]

Barr, D. J. S. 1970. Two varieties of Rhizophydium sphaerocarpum (Chytridales). Canad. Jour. Bot. 48: 1067-1071. [Typical variety includes *R. pollinis-pini,* studied from culture of original Michigan material.]

Bigony, Beatrice A. 1970. Lake Woodland occupations of the Saginaw valley. Mich. Archaeol. 16: 115-214. [Includes listing of 6 plant remains (mostly *Juglans*) from one

site at Saginaw; 15 from another Saginaw Co. site; and a few charred remains from a third.]

Bowers, Maynard Claire. 1969. A cytotaxonomic study of the genus Mnium in Colorado. Revue Bryol. Lichénol. 36: 167-202. [Cites chromosome numbers previously reported on Michigan material by Lowry.]

Brewer, Richard. 1970. Death by the plow. Nat. Hist. 79(7): 28-35, 110. [General account of prairies and oak openings, chiefly related to Kalamazoo Co. For a more narrow view of oak openings, see references by Peters, below.]

Clewell, Andre F., & Jean W. Wooten. 1971. A revision of Ageratina (Compositae: Eupatorieae) from eastern North America. Brittonia 23: 123-143. [Map shows several Michigan stations for *A. altissima* var. *altissima* (better known as *Eupatorium rugosum*).]

Davis, H. A., Albert M. Fuller, & Tyreeca Davis. 1970. Contributions toward the revision of the Eubati of eastern North America VI Cuneifolii. Castanea 35: 176-194. [This final paper of the series includes an index to the entire series and a supplement, in which *R. variispinus* (type locality: Kalamazoo Co.) is discussed as a species which cannot be placed but which belongs in the section Setosi rather than Arguti.]

Duncan, Wilbur H. 1971. The southern limits of Trientalis borealis. Rhodora 72: 489-492. [Distribution map shows records from 3 counties in Michigan. Records in U. of M. herbarium add another 36 and an additional 7 or more are in published literature; in short, the species is found throughout the State.]

Ervin, Edward L., & Glenn Syperda. 1971. Seasonal effects on soluble sugars and cytological aspects of Polygonatum canaliculatum rhizomes. Bull. Torrey Bot. Club 98: 162-167. [Study on material from Allegan Co.]

Haard, R. T., & C. L. Kramer. 1971 ["1970"]. Periodicity of spore discharge in the Hymenomycetes. Mycologia 62: 1145-1169. [Some of the data were obtained at the University of Michigan Biological Station.]

Harriman, Neil A. 1971. Records on the flora of Wisconsin. Rhodora 73: 60-61. [Mentions that the only Upper Peninsula records of *Satureja acinos* are from Mackinac Co.]

Hauke, Richard L. 1970. Terminology of the sporangial structures of Equisetum. Am. Fern Jour. 60: 162-163. [Interpretation based on population of *E.* ×*litorale* with abnormal cones, near Milan.]

Haynes, Robert R. 1971. A monograph of the genus Conopholis (Orobanchaceae). Sida 4: 246-264. [Distribution map includes Michigan stations for *C. americana.*]

Hinds, Harold R. 1970. Vertical distribution of lichens on aspens in Michigan. Bryologist 73: 626-628. [Study done east of Douglas Lake—which is not "in Pellston" but in the next county!]

Kapp, Ronald O. 1970. A 24,000-year-old Jefferson mammoth from Midland County, Michigan. Mich. Academ. 3(2): 95-99. [Includes mention of cones for four gymnosperm species in excavation at the site but considerably younger (3310 ± 160).]

Kaufman, Peter B., Wilbur C. Bigelow, Rudolf Schmid, & Najati S. Ghosheh. 1971. Electron microprobe analysis of silica in epidermal cells of Equisetum. Am. Jour. Bot. 58: 309-316. [Material of both species studied came from Washtenaw Co.]

Kral, Robert. 1971. A treatment of Abildgaardia, Bulbostylis and Fimbristylis for North America. Sida 4: 57-227. [Includes full treatment, with distribution maps, for the three Michigan species: *B. capillaris, F. autumnalis,* and *F. puberula.* St. Joseph Co. can be added to the map for the latter. See also comment on p. 31 of this issue.]

Largent, David L., & Robert G. Benedict. 1970. Studies in the Rhodophylloid fungi II: Alboleptonia, a new genus. Mycologia 62: 437-452. [*A. sericella* var. *lutescens* f. *lutescens* is cited from Michigan, the punctuation implying this is in Massachusetts.]

Lester, D. T. 1970. Variation in seedling development of balsam fir associated with seed origin. Canad. Jour. Bot. 48: 1093-1097. [Includes study of Michigan plants with special reference to frost damage.]

Löve, Askell. 1970. IOPB chromosome number reports XXV. Taxon 19: 102-113. [Includes report of n = 9 for *Panicum tsugetorum* from Cheboygan Co., by R. Spellenberg.]

Löve, Askell, 1970. IOPB chromosome number reports XXVIII. Taxon 19: 608-610. [Includes report by D. Vitt of N = 10 + 1m for the moss *Pylaisiella selwynii* from Cheboygan Co.]

MacDonald, Roderick L., Paul A. Delcourt, & Ronald O. Kapp. 1971. Plant communities of the MacCurdy Ecological Tract, Montcalm County, Michigan. Mich. Academ. 4: 17-28. [Background material on the "Vestaburg Bog" area.]

Malloch, David. 1970. *Wardomyces aggregatus* sp. nov. and its possible relationship to *Gymnodochium fimicolum.* Canad. Jour. Bot. 48: 883-885. [Type from Wycamp Lake, Emmet Co.]

Miller, Orson K., Jr., & Linnea Stewart. 1971. The genus Lentinellus. Mycologia 63: 333-369. [Five of the 8 species are cited from Michigan, without further locality data; two of them are illustrated by Michigan collections.]

Neuhauser, K. Sieglinde, & R. L. Gilbertson. 1971. Some aspects of bipolar heterothallism in Fomes cajanderi. Mycologia 63: 722-735. [One of the strains studied was a rot isolate from a telephone pole at Ann Arbor.]

Peters, Bernard C. 1970. No trees on the prairie: Persistence of error in landscape terminology. Mich. Hist. 54: 19-28. [Includes a map of "Pioneer Landscapes of Kalamazoo County." Attempts to demonstrate that "the Michigan pioneers used the terms oak openings and prairies for the same landscape" and that areas called "prairie" were always completely treeless. Selected quotations and quotations out of context appear to support the point. But cf. Brewer article cited above for references to burr oaks on prairies.]

Peters, Bernard C. 1970. Pioneer evaluation of the Kalamazoo County landscape. Mich. Academ. 3(2):15-25. [Oak openings were second only to prairies, and both were preferred over heavily timbered land, by the early settler. Includes same map as in previous paper, but with sources indicated.]

Pyrah, Grant Lloyd. 1969. Taxonomic and distributional studies in Leersia (Gramineae). Iowa St. Jour. Sci. 44: 215-270. [*L. virginica* is cited from Washtenaw Co. and mapped from an additional location; *L. oryzoides* is cited from Gilford [Tuscola Co.] and mapped from several localities.]

Robinson, William L. 1969. Habitat selection by spruce grouse in northern Michigan. Jour. Wildl. Managem. 33: 113-120. [Includes tables and discussion of vegetation on the Yellow Dog Plains, northwest Marquette Co.]

Seymour, Roland L. 1970. The genus Saprolegnia. Nova Hedwigia 19: 1-124. [Six species cited from Michigan.]

Smith, Alexander H., Harry D. Thiers, & Roy Watling. 1968. Notes on species of Leccinum. I. Additions to section Leccinum. Lloydia 31: 252-267. [Several new taxa described from Michigan, usually with at least the county designated, thus supplementing the treatment in Mich. Bot. 5: 131-179 (1966).]

Stuckey, Ronald L., & Jane L. Forsyth. 1971. Distribution of naturalized Carduus nutans mapped in relation to geology in northwestern Ohio. Ohio Jour. Sci. 71: 1-15. [Table of earliest known records from selected locations in northeastern North America includes ones from Schoolcraft and Washtenaw cos.]

Thompson, R. H. 1969. Sexual reproduction in Chaetosphaeridium globosum (Nordst.) Klebahn (Chlorophyceae) and description of a species new to science. Jour. Phycol. 5: 285-290. [Collections of *C. globosum* cited from Kalamazoo and "Berry" cos.; the new species (*C. gemmatum*) cited from Nymphaea leaves in Stoney Lake, Kalamazoo Co., but invalid because no type is specified.]

Tryon, Rolla. 1971. The process of evolutionary migration in species of Selaginella. Brittonia 23: 89-100. [Repeats an earlier distribution map showing 7 or 8 stations for *S. rupestris* in Michigan.]

Verme, Louis J. 1965. Swamp conifer deeryards in northern Michigan their ecology and management. Jour. Forestry 63:523-529. [Data from the Shingleton-Cusino area, Alger Co.]

Wagner, Warren H., Jr. 1971. Evolution of Dryopteris in relation to the Appalachians. pp. 147-192 in The Distributional History of the Biota of the Southern Appalachians. Part II. Flora (Perry C. Holt, ed.). Virginia Polytechnic Inst. Res. Div. Monogr. 2. [Includes considerable cytological data from Michigan species and hybrids.]

Editorial Notes

Thanks to several readers, our stock of scarce back issues is somewhat improved. The most serious "bottlenecks" now preventing making up more complete sets are both numbers of Vol. 1 (1962), Vol. 5 No. 1 (January, 1966), and Vol. 5 No. 3A (May, 1966). Anyone with copies to spare is invited to help restore our stock!

The October number (Vol. 10, No. 4) was mailed Oct. 20, 1971.

In Memoriam

Dale J. Hagenah, leading student of the flora of Michigan, died on October 30, 1971. After retiring in 1969 as a senior quality control engineer for Chrysler Corporation, he became curator of the herbarium at Cranbrook Institute of Science, where he had been a research associate since 1952. A full account of his life and work, with complete bibliography, is planned for our next issue.

E. Lucy Braun, noted plant ecologist, died at her home in Cincinnati, Ohio, on March 5, 1971, shortly before her 82nd birthday. Dr. Braun's *Deciduous Forests of Eastern North America* included the results of her field work in Michigan; and her volumes on the monocots and woody plants of Ohio are well known to many.

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CONTENTS

A Bryophyte Florula of an Area near Grand Ledge, Eaton County, Michigan
Norton G. Miller 3

Review—Common Wild Flowers of Minnesota 12

Studies in the Genus *Cortinarius*, II: Section Dermocybe, New and Interesting Species from Michigan
Joseph F. Ammirati & Alexander H. Smith 13

Additional Nomenclatural and Other Notes on Michigan Monocots and Gymnosperms
Edward G. Voss 26

Review—Wild Flowers of Ohio and Adjacent States 37

Tipularia discolor in Southwestern Michigan
William A. Schwab 38

Vertical Distribution of the Lichen Genus *Physcia* on Bigtooth Aspen, Northern Red Oak, and Red Maple at Douglas Lake, Michigan
Terry R. Haas & Andrew Clauson 39

Michigan Plants in Print 42

Editorial Notes 47

In Memoriam 47

(On the cover: Hoar-frost on a winter morning, photographed near Cedarville, Michigan, by Doug Fulton, February 4, 1968.)

...33
...11 #2

Vol. 11, No. 2

THE

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors should be guided by "Information for Authors" (Vol. 9, p. 62; copies available from the editor).

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STUDIES ON MICHIGAN CHRYSOPHYCEAE. I.

Daniel E. Wujek and Ralph Hamilton
Department of Biology,
Central Michigan University, Mount Pleasant

This paper is intended as the first in a series dealing with species of Chrysophyceae occurring in samples collected from some lakes and ponds in Michigan. It includes discussion of *Mallomonas* spp., *Synura* spp., and *Chrysosphaerella* spp. and notes on vegetation, temperature and chemistry of the waters at the time of sampling, if available.

DESCRIPTION OF LOCALITIES

The species reported herein were collected from a variety of habitats in central and north central portions of the Lower Peninsula of Michigan and on Beaver Island in northern Lake Michigan. During the period May to August, 1971, plankton samples were gathered from surface waters located on Beaver Island (Lake Geneserath, Barney's Lake, Lake Michigan, Miller's Marsh, Fox Lake, and two beach pools directly north of the CMU Biological Station), Charlevoix Co.; Bird's pond, Ogemaw Co. (Cumming Twp., Sec. 6); and two small ponds on the properties of E. Delater and L. Koehler (Deerfield Twp., Sec. 25 and 26 respectively) and Lake Isabella (Sherman Twp., Sec. 34 and 35, Broomfield Twp., Sec. 2 and 3), Isabella Co.

Chemical analyses were made at the time of sampling from the following sites:

	pH	water temp. (C)
Lake Michigan	7.2	20
Fox Lake	6.6	21
Barney's Lake	8.4	24
St. James Harbor	7.5	17.5
Lake Geneserath	—	21
Miller's Marsh	6.1	23

Bird's pond and the two Isabella County ponds are spring-fed and all had abundant growth of *Chara* present at the time of sampling.

METHODS

Most species were first examined in live condition with an optical microscope. For electron microscopy, a suspension of either live or preserved material was dried directly on Formvar coated 200 mesh copper grids. All plankton samples were subsequently preserved in 5% gultaraldehyde. All electron micrographs were made using a Philips EM300 electron microscope.

An asterisk before the name indicates a taxon here first reported for the state.

MALLOMONAS

Mallomonas species are unicellular, free-swimming, freshwater organisms covered with silica scales that form a flexible armor. The scales may bear movable bristles or immovable spines. Structure of scales and spines and numbers and structure of bristles are important taxonomic features. Each scale consists of a delicate plate perforated by more or less regularly spaced minute holes. On the plate foldings, ridges, papillae, etc. are present. A certain group of species has tripartite scales consisting of a dome, shield, and flange (Asmund & Hilliard, 1961). Figure 1 shows what is meant by these designations. A more detailed description of tripartite scales is given by Harris (1953), Harris and Bradley (1957), and Asmund (1969).

The first electron micrographs of *Mallomonas* scales were taken in 1951 and published a few years later by Fott (1955). Presently, no description of *Mallomonas* is considered complete unless it includes an electron micrograph of the scales.

**Mallomonas papillosa* Harris & Bradley (Fig. 2)

This is a very small species, which can only be recognized by means of EM. It was described from England (Harris & Bradley, 1957) and has later been reported from Japan (Takahashi, 1959), Alaska (Asmund & Hilliard, 1961), Scotland (Bradley, 1966), and Sweden (Kristiansen, 1969). The characteristic structure of the scales is as described and pictured by the workers referred to above. This species was found in Barney's Lake.

**Mallomonas monograptus* Harris & Bradley (Fig. 3)

We have found *M. monograptus* to be easily recognizable in its mature form with the optical microscope. This species was the most widespread of the *Mallomonas* species observed in this study. It occurred in Lake Isabella, Barney's Lake, Lake Geneserath, and Lake Michigan.

**Mallomonas pseudocoronata* Prescott

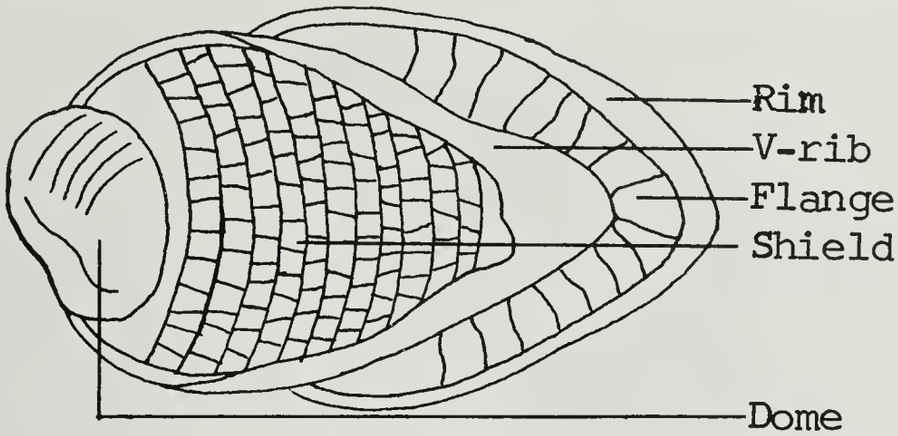
The species, described by Prescott from material collected in Wisconsin, was observed from a plankton tow collected outside St. James Harbor. An extended description of the species is given by Asmund and Hilliard (1961) for their Alaskan material.

**Mallomonas arkokomos* Ruttner (Fig. 4)

Electron micrographs of this species are described by Asmund (1956), Harris (1958), and Asmund and Hilliard (1961). A Michigan specimen from Bird's pond corresponds in all details to the previously described specimens.

**Mallomonas pumilo* Harris & Bradley (Fig. 5)

Electron micrographs of this species were first published by Harris and Bradley (1957) followed by Asmund (1959), Asmund and Hilliard (1961), and Asmund and Takahashi (1969). The scale illustrated appeared in the samples taken from Bird's pond.



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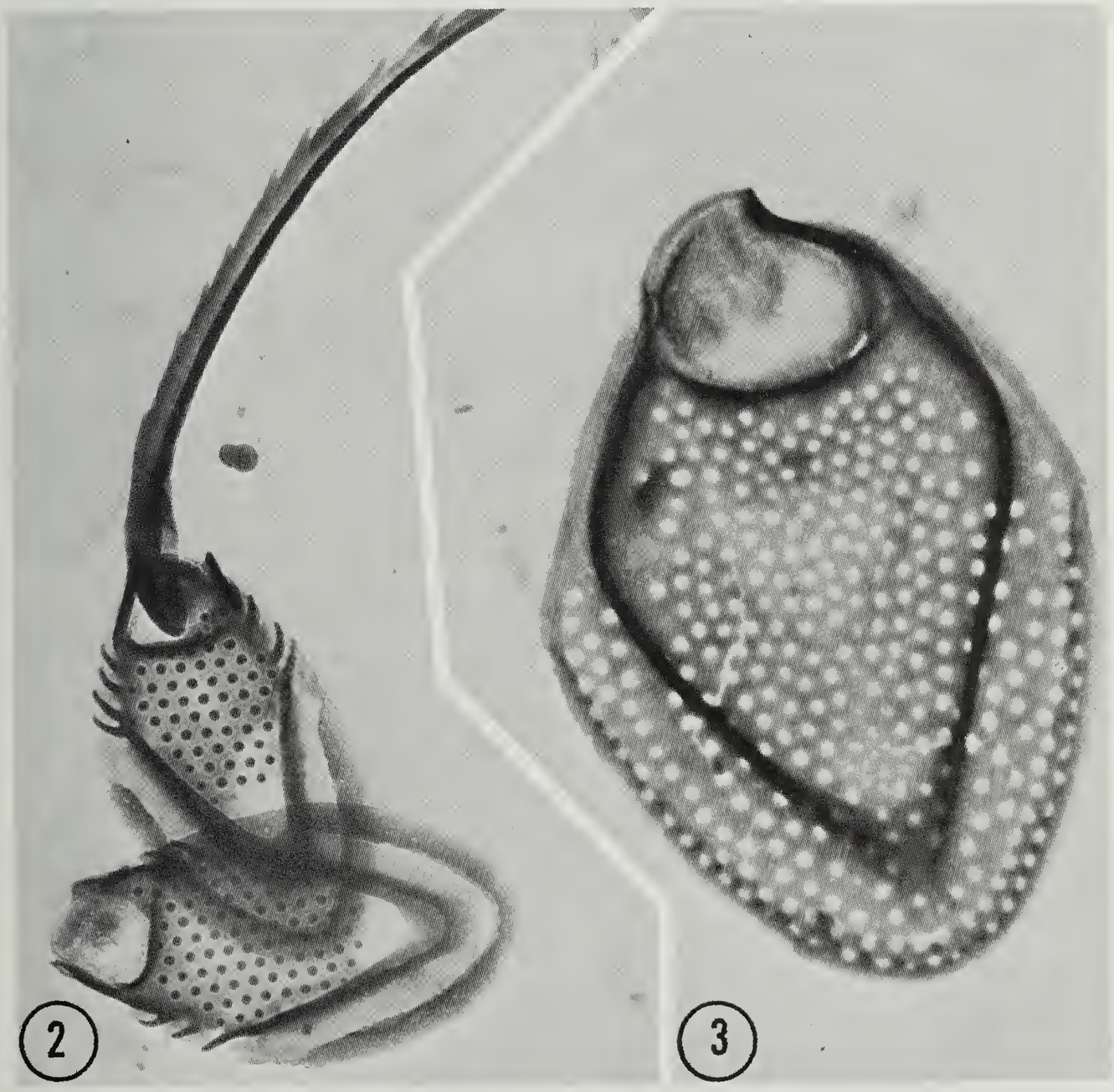

Fig. 1. Diagram of a tripartite scale of *Mallomonas* as seen in the electron microscope (after Fott, 1962). Fig. 2. *Mallomonas papillosa,* ×16,200. Fig. 3. *M. monograptus,* ×19,300.

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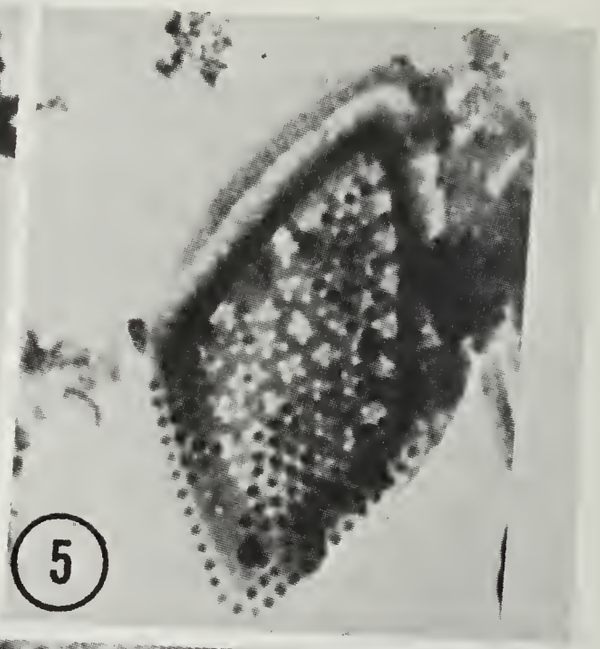
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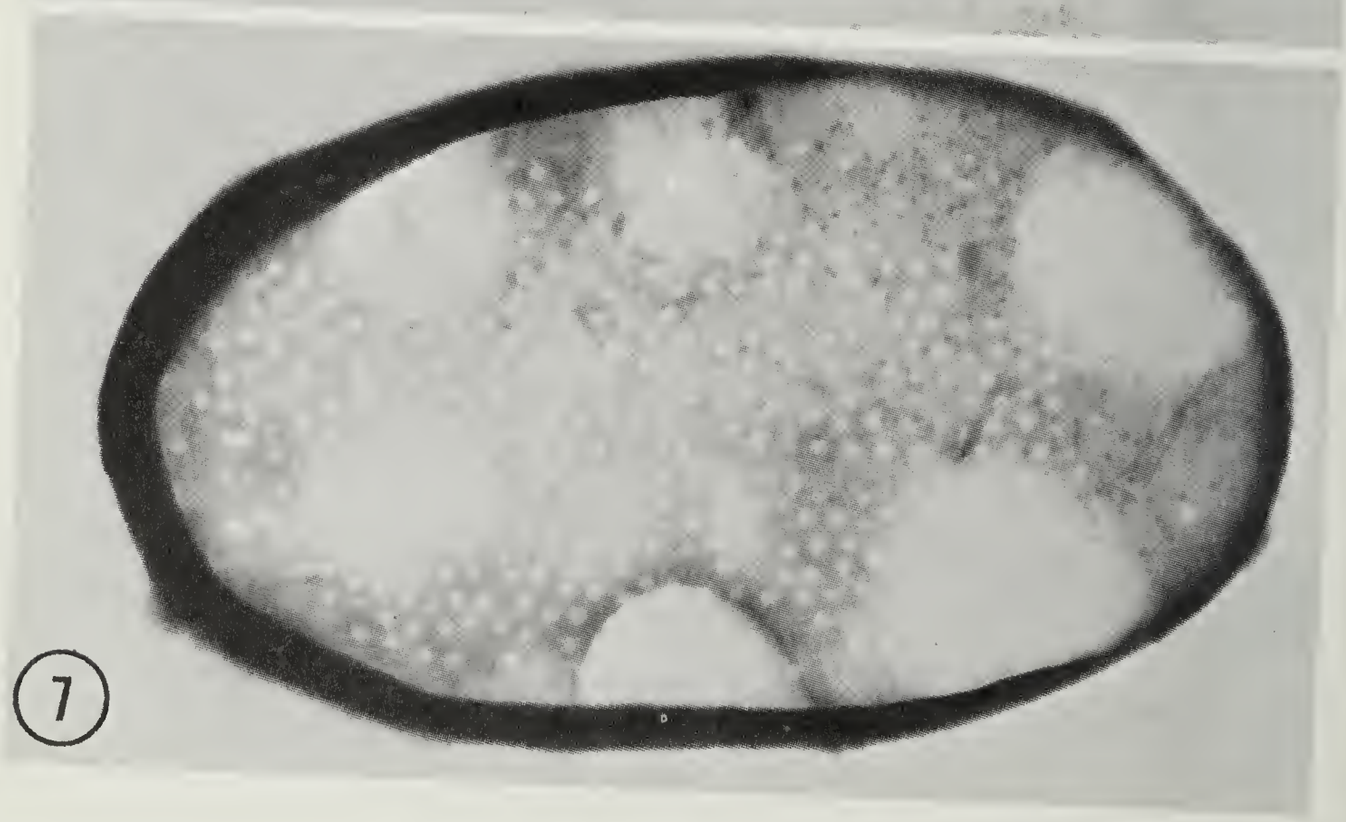
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**Mallomonas flora* Harris & Bradley (Fig. 6)

Scales of this species were found in Bird's pond.

Mallomonas caudata Iwanoff emend. Krieger (Fig. 7)

The occurrence of *M. caudata* in Michigan was reported earlier (Prescott, 1961). It is a very adaptive form with a world-wide range. Its occurrence in Fox Lake, a dystrophic lake, fits well its occurrence in other highly colored lakes in other parts of the world.

SYNURA

The cells of the alga are radially united in spherical to oblong motile colonies that are not enclosed by a gelatinous sheath. The individual cells are pyriform in shape. The scales of most members of this genus have been well studied with an electron microscope (Petersen & Hansen, 1956), but it is often difficult to relate their shape to the picture of the colony of *Synura* cells as seen under the light microscope. Bristles or spines are not present.

**Synura petersenii* Korshikov (Fig. 8)

Manton (1955) examined in the electron microscope the scales of *Synura caroliniana* Whitford from North Carolina; so far as we know these were the first *Synura* scales examined in the electron microscope. Petersen and Hansen (1956), comparing the micrographs of *S. petersenii* with those of Whitford's species, found that the two species were identical. Later on many authors have carried on electron microscope examinations of scales of *S. petersenii* and it is now one of the best known and commonest *Synura* species. Scales from this species occurred in all the samples, except the Fox Lake and beach pool collections.

**Synura sphagnicola* Korshikov (Fig. 10)

As has been demonstrated in a previous study (Kristiansen, 1969), this species usually occurs in lakes that are acid and brown-watered. Our observations confirm this for we have noted its presence in Miller's Marsh and Barney's Lake.

**Synura spinosa* Korshikov (Fig. 9)

The scales are of the same ultrastructure as previously reported by various authors. Representative scales are found in collections from Miller's Marsh, Lake Geneserath, Barney's Lake, Lake Michigan, and beach pool #1.

CHRYSOSPHAERELLA

The large colonial organisms of the genus *Chrysosphaerella* with numerous spines are easy to find with the light microscope. Differentiation of the species is, however, a difficult matter and can only really be achieved with an

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Fig. 4. *M. akrokomos,* ×19,300. Fig. 5. *M. pumilo,* ×15,800. Fig. 6. *M. flora,* ×20,000. Fig. 7. *M. caudata,* ×19,800.

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electron microscope. The taxonomy of the genus is discussed in detail by Harris and Bradley (1958) and Peterfi (1966).

**Chrysosphaerella longispina* Lauterborn emend. Korshikov (Fig. 11-13)

A thorough examination of the silica scales and spines by means of light microscopy suggested that our specimens were identical with *C. longispina,* but when observed under the electron microscope, they were identical to the electron micrographs published by Bradley (1964) as *C. multispina.*

Bradley distinguishes his species (*C. multispina*) from *C. longispina* by the numerous short spines and the structure of the scales. Unfortunately, *C. longispina* has not been examined by electron microscopy, at least by anyone willing to designate their material as such. Korshikov (1942), in addition to describing *C. brevispina,* noted that specimens of an organism he called *C. longispina* had only 3-5 long spines, and the scales had no reticulate structure, but only spokes radiating from an inner ring to the margin. Korshikov's observations, however, are not quite in accordance with those made by Lauterborn (1899). The *Chrysosphaerella* described by Lauterborn had two spines on each cell. The scales were elliptical, but he did not describe their structure. In addition, Lauterborn found many numerous very short spines as pointed out by Kristiansen (1969). Unfortunately, he did not illustrate these spines. We are convinced from the above that *C. longispina* and *C. multispina* are the same species. This can only, however, be settled by the electron microscopy of the original material or from material from the respective localities.

Our specimens were collected from Barney's Lake and Lake Michigan.

**Chrysosphaerella brevispina* Korshikov emend. Harris & Bradley (Fig. 14-15)

The electron micrographs of scales and spines agree with those of Fott and Ludvik (1956), Harris and Bradley (1958), and Peterfi (1966). We believe that the small differences in the structure of spines by comparison with those previously published are within the normal variation of the species. *Chrysosphaerella brevispina* was observed from collections taken from Barney's Lake, St. James Harbor, and beach pool #1.

SUMMARY

The Chrysophycean species found in samples from a variety of freshwater habitats were identified by electron microscope studies of their scales. Notes on their ecology are given.

Of the 12 species observed in this study, 11 are new to Michigan. With the exception of *M. pseudocoronata, Mallomonas* which are new to the state have also not been reported previously for the continental United States, viz. *M. akrokomos, M. flora, M. monograptus, M. papillosa,* and *M. pumilo.*

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Fig. 8. *Synura petersenii,* ×18,700. Fig. 9. *S. spinosa,* ×19,600. Fig. 10. *S. sphagnicola,* ×11,100.

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ACKNOWLEDGMENTS

This study was in part financed by NSF Institutional and Research and Creative Endeavor Committee grants. We wish to thank Dr. M. H. Hohn for use of the facilities at Central Michigan University's Biological Station.

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Fig. 11-13. *Chrysosphaerella longispina,* ×6,300; 15,900; 21,500. Fig. 14-15. *C. brevispina,* ×23,800; ×15,625.

Dale J. Hagenah, 1960

DALE J. HAGENAH (1908-1971): AN OUTSTANDING MICHIGAN BOTANIST

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The University of Michigan, Ann Arbor

Those of us who knew the late Dale J. Hagenah recall his modesty. He would have been surprised and perhaps a little embarrassed to hear himself referred to as an "outstanding Michigan botanist," yet this is just what he was. His publications, his plant collections, and his interactions with botanists in many parts of the country and the world were carried out purely as a "sideline." Persons familiar only with his publications may be surprised to learn that botany was not his profession. He was not even trained in this field. For practically the entirety of his adult life, Dale Hagenah was connected with industry. Beginning in 1934, he was employed by the Chrysler Corporation of Detroit as an inspector and an expert in the field of quality improvement in the manufacture of automobiles. By 1959 he had been promoted to Senior Quality Control Engineer, and he remained in this role until late 1969 when, following serious illness, he retired so that he could devote full time to his avocation of botany.

He was born on June 23, 1908, at Manton, Wexford County, Michigan. The family moved subsequently to a farm in northern Kent County, north of Grand Rapids. He attended high school at Cedar Springs and followed this by two years at Grand Rapids Junior College, where he studied business administration and received the Associate degree in 1929. In 1935, Hagenah received his B.S. in Commerce from Northwestern University's School of Commerce in Chicago, but he continued to take courses related to his profession at various other universities until the 1950's. For nearly twenty years he was active as an officer and committee member in the American Society for Quality Control. In the Chrysler Corporation his duties were diverse, involving inspection, supervision, personnel relationships, "trouble-shooting" problems in production, and so on. He was, nevertheless, able to maintain an active research program on Michigan botany as a hobby, and became increasingly more active in this field.

His interest was stimulated through association with the now defunct Detroit Academy of Natural Sciences and particularly the Cranbrook Institute of Science. In the middle 1940's Cranbrook had begun to attract a number of devoted amateur botanists who typically spent one evening a week identifying plants of which many were their own collections. Wives of the several members came, too, and helped out by mounting specimens, preparing labels, and filing finished sheets in the steadily growing herbarium. It was all a labor of love, and lots of fun. It was at this time that Dale's wife, Ethelda, always known as "Teddy," developed her botanical interest along with her husband. As the years went by, the group often made weekend field trips to collect in poorly represented counties or to look for certain rare species. The evenings tended to become longer as showings of Kodachromes became frequent and midnight

suppers the rule. It was on the field trips that many a rare fern or orchid was first seen growing and that interesting and sometimes new forms were discovered. Teddy formed a strong partnership with Dale with her bright eyes often spotting something others had passed over.

Whether or not "God loves an amateur," as someone has said, Cranbrook benefited greatly from this group which sometimes was as large as ten or twelve participants on some of the night sessions. It was during this period that Dale began to develop the understandings that made him so professional in his abilities and knowledge. After joining the Cranbrook Herbarium Committee when it was officially formed in 1947, he was encouraged by the staff members there to carry out his own research projects. In 1952 he was named a Research Associate of the Institute, and in 1969, after he retired, he was appointed the Curator of the Herbarium.

In the 1940's and early 1950's his involvement in natural history was broad, and he served as a member of the Board of Directors of the Detroit Audubon Society and also, for several years, as secretary and president of the Detroit Academy of Natural Sciences. In the late 1940's he became interested in the Botany Section of the Michigan Academy of Science, Arts, and Letters, and he presented a number of papers over the years. He was Vice Chairman of the Botany Section in 1956 and was serving again in this capacity at the time of his death. To the Michigan Botanical Club he was likewise a strong contributor of time and energy, and he presented talks, led field trips, and also presented a course in the recognition and identification of ferns for the Southeastern Chapter (1965). At the national level, he was one of our leading non-professionals in the American Fern Society, corresponding with members and exchanging information, as well as conducting and helping in the planning of field forays; in 1953 he led a six-day field trip in connection with the American Institute of Biological Sciences meetings, and he also contributed to the planning of others in Ohio and southern Michigan.

From its beginnings in 1951, Dale Hagenah found the Michigan Natural Areas Council an ideal group in which to share his knowledge and viewpoints concerning wilderness and wildlife. The Natural Areas Council is unique.[1] No other state has such an organization. The success of the council has depended not only on the concept of a citizens' group recommending to the State that certain natural areas be given complete protection because of their biological richness and undisturbed naturalness, but also on making the case for protection by thorough and competent description of the values involved. The evidence of its success lies in its lasting quality and also in the fact that every area it has recommended has been accepted for dedication by the Natural Resources (formerly Conservation) Commission. Dale loved the natural areas of the state as well as the Upper Great Lakes in general, and he knew these areas as well as, if not better, than most of his colleagues, so his advice was invaluable. He was called upon repeatedly to serve on reconnaissance and site committees for the

[1]See Ronald O. Kapp, Natural Area Preservation in the Age of the Megalopolis, Mich. Bot. 8: 30-35. 1969.

evaluation of natural areas and recommendation as to how they should be dedicated. His comments and suggestions were terse and to the point and reflected his desire for facts and caution. For this reason we often went to him for advice, knowing that it would be sound and would invoke high standards. We must include him among the pioneers in Michigan in recognizing the vast importance of saving prime examples of the different types of ecological communities and sites where rare and disappearing plants and animals are found. As a member of the executive committee of the Michigan Natural Areas Council, he was participating in meetings concerned with the Porcupine Mountains State Park until only three weeks before his death.

There were a number of facets to Hagenah's research, including distribution of orchids, literature and history of research on plants of Michigan, and in particular the ferns and their allies. In the late forties and in the fifties, his research emphasized almost exclusively exploration, especially of the Bruce Peninsula in Ontario, and the Huron Mountains on the south side of Lake Superior including adjacent parts of Marquette Co., Michigan (see bibliography, 1962a, 1963). Many of the results of his work are contained in his publications but he was involved in several uncompleted projects at the time he died. The latter include further investigations of the fragile ferns, the determination of pteridophyte distributions in the Upper Great Lakes region, and the distribution and taxonomy of clubmosses. It is somewhat difficult to summarize his work because much of it was in the form of unpublished collaborations with other botanists. He worked closely at different periods of his research career with a number of individuals, including Stanley A. Cain, Rogers McVaugh, Marion T. Hall, Warren P. Stoutamire, James R. Wells, W. H. Wagner, Jr., Florence S. Wagner, and a number of others. He always gave willingly of his time to worthwhile projects.

His published papers appeared in the journals of the New England Botanical Club (*Rhodora*), American Society of Plant Taxonomists (*Brittonia*), American Fern Society (*American Fern Journal*), and Michigan Botanical Club (*Michigan Botanist*). (It is noteworthy that the first scientific article which appeared in *The Michigan Botanist* dealt with clubmosses and was written by Dale Hagenah, 1962b.) He collaborated with Stanley A. Cain in bringing *Ferns of Michigan* by Cecil Billington to completion. Billington, who died in 1950, had left a still unfinished manuscript, and the job of completing it was assigned to Cain and Hagenah by the then Director of the Cranbrook Institute of Science, Dr. Robert T. Hatt. This was Hanenah's first major experience at detailed herbarium work, and he gathered the fern records from the collections of Aquinas College, Grand Rapids Public Museum, and, in part, the University of Michigan Herbarium. Together with Cain and Paul W. Thompson, he also devoted much of a summer's free time to field work to fill in the distribution records. As an outgrowth of these studies, Hagenah continued field and herbarium investigations, and published many new records (practically all his own) for Osmundaceae, Polypodiaceae, and Ophioglossaceae (1955, 1966).

Not surprisingly his viewpoint included the entirety of Michigan botany and its history, and he was a strong promoter of work on the plants of this state.

In one of his earliest articles he declared the study of Michigan flora to be an opportunity for local botanists (1953a). He became one of the co-authors of an account of the life and work of the well known Michigan botanist, Oliver A. Farwell (1953c) and his opinion was frequently sought as the court of last resort in interpreting Farwell's often chaotic and contradictory data; in his last days, he was unravelling some of the Farwell mysteries. Dale's interest in the Michigan flora and his frequent field excursions led him to seek out and become acquainted with amateur botanists around the state. Mr. and Mrs. Clarence R. Hanes of Kalamazoo County, who published a flora of that county, were friends of the Hagenahs. It is probably as much that association as anything else which led to the trust fund established by Mrs. Hanes' will, for the publication of a flora of Michigan—the first volume of which is now being printed.

Dale Hagenah will probably be remembered most for studies of particular problems concerning pteridophytes, involving detailed examinations of single species or groups of closely related ones. It was really due to his efforts that the famous Hart's-tongue fern, *Phyllitis scolopendrium* var. *americanum,* was finally discovered in Michigan—a beautiful example of botanical detective work, in which he followed the geological occurrences of the Niagara dolomitic limestone. After some years of study, both in the library and in the field, he finally found a locality where the desired plant grew. In company with M. T. Hall, he encountered the first Michigan population in Chippewa County, some 190 miles north and west of the previously known limit in the Bruce Peninsula, Ontario.

Among the other special problems he was concerned with, those involving fragile ferns, *Cystopteris;* woodferns, *Dryopteris;* and clubmosses, *Lycopodium*, especially attracted his efforts. He became interested in fern spores as a means of differentiating species and hybrids. As a result he detected for the first time many new localities of the rather mysterious plant called *"Cystopteris dickieana,"* the taxonomic status of which is still in question but which displays a spore type differing radically from the typical spore of its genus (1961); he also found small spores in the fragile fern complex for the first time, and this is what led to the recognition that the spreading bladder fern, formerly interpreted as a variety of *C. fragilis* was actually a distinct species, *C. protrusa* (1956a). Hagenah devoted much attention to the field study of curious fragile ferns in which highly distorted and diseased-appearing outgrowths form upon the rachis (1957). To him we owe the field discovery of a number of rare and remarkable woodfern hybrids, including two—*Dryopteris assimilis* (so-called "Lake Superior dilatata") × *marginalis* and *D. assimilis* × *intermedia*—which proved to be new to science. For research on the woodferns, he and Ethelda Hagenah maintained a collection of plants alive in the garden of their home in Birmingham, and from these plants many new chromosome counts and other studies were made by researchers at the University of Michigan.

Clubmosses, *Lycopodium,* of the Great Lakes area intrigued Hagenah, partly because so many of them appeared in one of his favorite ecological sites—the so-called "borrow pits," i.e., excavations made along new highway projects to obtain soil for building up roadbanks, exit and entrance ramps, and

so on. In such places, during the early stages of succession (approximately 5 to 15 years after excavation), many rare plants appear spontaneously, including certain orchids and pteridophytes. He discovered that such places are often ideal for the growth of various clubmosses, but in particular the bog clubmosses (group of *L. inundatum*) and the fir clubmosses (*L. selago* and its presumed hybrids). On this subject *per se* he wrote only a single paper (1962b), but the results of this work, in terms of information communicated to others and his precisely labeled herbarium collections, will undoubtedly have important spin-off in the future.[2]

Hagenah's herbarium collections emphasized pteridophytes, but included other plant groups as well. He collected unicates usually, and his specimens are characterized by high quality and extremely accurate locality data. The vast majority of his collections are in the herbarium of the Cranbrook Institute of Science, with some duplicates at the University of Michigan.

We have already mentioned his interactions and cooperation with a number of established professional botanists, but we have no precise record of how many manuscripts of scientific articles he read and criticized for the improvement of the contents. We do not have records, either, of how many college students Hagenah helped, especially graduate students carrying out research on the plants of the Upper Great Lakes area. His comprehensive cross-referenced bibliography of Michigan botany, although unpublished, was a valuable aid in local studies.

Dale Hagenah's contributions to botanical science have been commemorated by the description in 1968 by W. J. Cody of the Plant Research Institute, Canada Department of Agriculture, of a new hybrid holly-fern, *Polystichum* ×*hagenahii,* an exceedingly rare plant, discovered only once, growing near the parents in the Bruce Peninsula. It was a remarkable plant which combined the characteristics of the Christmas fern and the northern holly-fern.

Dale Hagenah died on October 30, 1971. One of our major contributors to the cause of natural history and conservation in Michigan, he was also a foremost example of an individual's love for knowledge and exploration. He carried out his research and field exploration on his own time and largely at his own expense. To have had combined in one person such a deep interest in science and conservation with such a willingness and ability to give aid and inspiration to others is a rare event indeed. What Dale Hagenah left to us in the form of high principles of conservation, his plant collections, and the results of his research is a fitting monument to a dear friend.

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[2]The results of his *Lycopodium* studies, including a first report of a new bog clubmoss for Michigan, were presented in papers read at meetings of the Michigan Academy: "The habitat and distribution of *Lycopodium inundatum* in Michigan" (Michigan State U., 1969); "The bog clubmoss in some man-made habitats" (Wayne State U., 1970); and "A coastal plain clubmoss, *Lycopodium appressum,* in the Great Lakes area" (Western Michigan U., 1971).

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News of Botanists

On June 7, Secretary of the Interior Rogers Morton presented Distinguished Service Awards to nine National Park Service employees, including Dr. Robert M. Linn, chief scientist, Office of Natural Science Studies, who was chief park naturalist 1956-1963 at Isle Royale. ... Dr. Harold B. Tukey, who sat at Liberty Hyde Bailey's old desk as head of the Horticulture Department at Michigan State University from 1945 until his retirement in 1963, died in Florida November 8, 1971. ... HONORS TO OUR MEMBERS: Clarence Messner, honorary member of the Michigan Botanical Club, has been awarded a certificate of merit from the Michigan Chapter of the Soil Conservation Society of America for his contributions to the cause of soil and water conservation. ... Western Michigan University awarded an honorary doctor of humanities degree last year to Gwen Frostic. Dr. H. Lewis Batts, Jr., of Kalamazoo College and the Kalamazoo Nature Center, received an honorary doctor of science degree. ... Doug Fulton, outdoor editor of the Ann Arbor *News* (and frequent supplier of our cover pictures) received the Paquin Award for the best contribution to conservation at the summer meeting of the Michigan Outdoor Writers Association, for a series of articles on the Porcupine Mountains.

WOLFFIA IN THE BLADDERS OF *UTRICULARIA*: AN "HERBIVOROUS" PLANT?[1]

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Aquatic plants of the genus *Utricularia* (bladderworts) are characterized by the float-like traps or bladders on the leaves, which are actually small, highly specialized structures that capture and digest animal prey. Bladderworts may ingest almost any small aquatic animal, as the adjectives "carnivorous," "insectivorous" (Lloyd, 1942), and "piscivorous" (Halperine, 1885), describe. Phytoplankton is often found in the traps, but the capture of *Wolffia* (duckweed, watermeal) or other vascular plants has not been recorded.

While collecting aquatic plants along western Lake Erie, I found two species of duckweeds, *Wolffia columbiana* Karst. and *W. punctata* Griseb., in the traps of *Utricularia vulgaris* L. (Fig. 1). The duckweeds and bladderworts occurred in a ponded bay of Lake Erie near Locust Point in Ottawa County, Ohio. I observed the plants throughout the summer and found *Wolffia* occurring in the traps on all visits. On some stems of *U. vulgaris* as many as ten percent of the traps contained *Wolffia,* with as many as five to a trap. Only the larger well-developed traps on mature portions of stems contained *Wolffia* plants. In most cases *Wolffia* thalli could be observed and identified to species through the translucent wall of the trap. *Wolffia columbiana* was much more common in the traps than *W. punctata.* Because of the purely mechanical nature of the trap, *U. vulgaris* is not selectively predaceous. Rather, this difference in abundance of *Wolffia* in the traps was probably a result of the diversity and complexity of the duckweed community.

Several acres of the shallow pond were completely covered with a thick mat of duckweeds. In order of decreasing numbers of individuals the community consisted of *Wolffia punctata, W. columbiana, Lemna minor, Spirodela polyrhiza,* and a floating fern, *Azolla caroliniana.* The latter formed almost closed mats of local occurrence, but the duckweeds formed a mixed and variable mat. *Wolffia punctata* was more abundant in the pond than *W. columbiana,* although the reverse abundance was noted in the traps. The duckweed mat was vertically stratified throughout the pond, but with considerable local variations in species abundance. In much the same way that a forest community has a canopy and subcanopy, the mat had distinct layers of species because of differences in their morphology and buoyancy. *Lemna minor* and *Spirodela polyrhiza* were aspect dominants owing to their larger size. *Wolffia punctata* appeared to be more buoyant than *W. columbiana* and

[1]Contribution from the Botany Department (Paper No. 807), the Herbarium, and the Franz Theodore Stone Laboratory.

floated at the surface between the thalli of the two larger duckweeds. *Wolffia columbiana* was mostly submerged and often hidden by the other duckweeds.

Submersed plants were uncommon in the shallow portion of the pond heavily shaded by the duckweed mat. In addition to *Utricularia vulgaris,* the following were noted: *Potamogeton foliosus, Ceratophyllum demersum, Elodea canadensis,* and *Lemna trisulca.* Of these, *U. vulgaris* and *L. trisulca* were unattached, whereas the others were attached. The bladderwort plants were usually over four feet long and had many branches extending horizontally just under the surface of the water. The leaves of *U. vulgaris* were spread parallel to the water surface and came into intimate contact with the lower portion of the duckweed community, where the *W. columbiana* plants were most abundant. A slight amount of disturbance in the shallow pond could easily have caused sufficient contact between duckweeds and bladderworts to spring the traps and result in the capture of *Wolffia.* This disturbance could have been caused by waves, wind, or fish. Whatever the disturbance in the pond it must have occurred many times during the three-month period of the study. I took great care while collecting not to cause a disturbance which would spring the traps in the presence of the duckweeds. However, watermeal was still found in the traps.

Live *U. vulgaris* plants, which were collected from the pond and kept in an aquarium for three weeks, did not appear to digest the *Wolffia* plants that

Fig. 1. A trap of bladderwort (*Utricularia vulgaris*) containing *Wolffia punctata* (upper left) and *W. columbiana* (upper center), about ×14. (From material collected 13 July 1971.)

were in the traps. Although some *Wolffia* plants became chlorotic and decomposed (appearing similar to some plants floating free in the same aquarium), others continued to live and bud. Lloyd (1942) mentioned that *Euglena* and diatoms have been known to live and reproduce in the traps, apparently unaffected by the digestive processes. The wall of the trap itself is certainly not severely affected, so it is possible that the digestive process does not have a total deleterious effect on the captured plants. Although *U. vulgaris* is usually considered carnivorous, this unusual interaction between bladderworts and duckweeds is evidence that *U. vulgaris* may also be considered "herbivorous."

SPECIMENS CITED

The following specimens document the identifications and observations: OTTAWA CO., OHIO: In ponded bay along state route 2, NE ¼ Sec. 2, T7N, R15E, Carroll Twp., ca. 1 mi w of Toussaint Creek, adjacent to the Locust Point Nuclear Reactor site, 13 Jul 1971 (OS).

Utricularia vulgaris L.: Common in 6 inches to 2 feet of water, with *Wolffia columbiana* and *W. punctata* in the traps, *M. L. Roberts 1325.*

Wolffia columbiana Karst.: Abundant, forming an extensive floating mat with *W. punctata, Lemna minor,* and *Spirodela polyrhiza, M. L. Roberts 1320.*

Wolffia punctata Griseb.: Abundant, forming an extensive floating mat with *W. columbiana, Lemna minor,* and *Spirodela polyrhiza, M. L. Roberts 1321.*

ACKNOWLEDGMENTS

The field study was conducted while I was a botany assistant at the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio. Special thanks are extended to Dr. Loren S. Putnam, director of the laboratory, Dr. Ronald L. Stuckey for assistance with the manuscript, and the Ohio Biological Survey.

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Halperine, E. 1885. Plantes piscivores. La Nature 13(632): 84-86. 11 July 1885, Paris. (translated by Herman Jacobson. 1885. Piscivorous plants. Bull. U.S. Fish Comm. 5:353-356).

Lloyd, Francis Ernest. 1942. The Carnivorous Plants. Chronica Botanica Co., Waltham, Mass. 352 pp.

THE HABITAT AND ORIENTATION OF CAPSULES OF *BUXBAUMIA APHYLLA* IN THE DOUGLAS LAKE REGION OF MICHIGAN

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The Buxbaumiaceae have long been considered a unique group of mosses owing to their small size and extraordinary form. The plants, annual, scattered, and not likely to be seen by any but a bryologist, consist of few if any leaves, a short, erect, roughened seta, and an asymmetric capsule which is large in comparison with the rest of the plant (which is very much reduced). The leaves, clustered at the base of the seta, disappear before the capsule ripens; the mature plant thus consists essentially of sporophyte and protonema. The capsule tapers from a broad base to a small, off-white mouth; in color it varies from chestnut to yellow-brown. Two species occur in Michigan, *Buxbaumia aphylla* Hedw. and *B. minakatae* Okam., the latter known from a single collection in Kalamazoo County. The purpose of this investigation was to study the habitats in the vicinity of Douglas Lake, in Cheboygan County, in which *Buxbaumia aphylla* is found and to determine whether or not there is any regularity in the orientation of capsules. The capsules are tear-shaped, the narrow mouth resembling the point of a tear, and they usually seem to "point" in the same direction, toward the greatest incidence of light.

The area of investigation is located in the northern tip of the Lower Peninsula of Michigan, between Lake Michigan to the west and Lake Huron to the east, and more specifically, between Douglas Lake and Burt Lake. The region is a transition zone between the northern coniferous forests and the central deciduous forests, The mineral soil, of glacial origin, is primarily made of sand. Fire has played an extremely important role over the past 80 to 90 years. At the beginning of lumbering operations in the 1870's, the uplands were either pine or beech-maple forests; lowlands were cedar swamps or marshes in depressions along streams. At present, the woods are largely aspen stands with a dense undergrowth of *Pteridium aquilinum.* Investigations into the local occurrence of *Buxbaumia* were made in such areas of second-growth aspen. *Buxbaumia aphylla* grows in disturbed places, especially where there has been a fire, where larger, more vigorous plants have not yet had a chance to take hold and provide competition. It is most readily found on decayed wood or wood humus. In the Douglas Lake area, great numbers of *B. aphylla* occur as scattered individuals or in clusters in open, pioneer situations in the young aspen forest. No doubt the history of cutting and burning of forests can account, in part, for the local abundance of a species ordinarily considered very rare and localized in distribution.

The method used in this investigation involves more subjectivity than normally allowed in sampling. However, the purpose was to determine the plants which are associated with *B. aphylla* and the nature of the larger

community in which it is usually found, rather than the frequency and distribution of the species in the area. It was decided, therefore, that the subjectivity involved in choosing clusters of *B. aphylla* to sample was justified.

With this decision made, a 20 cm quadrat frame was marked into 1 cm sections. This size was sufficient to include a representative sample of *B. aphylla* and the plants immediately associated with it, both minute plants and others up to the size of *Pteridium aquilinum.* From each of ten 20 cm quadrats, samples were taken back to the laboratory for identification of more minute plants. Each capsule of *B. aphylla* was drawn to scale on a graph, as a means of recording directional orientation.

In addition to notes taken in the field on the nature of the surrounding community, the trees in a circle of radius 5 m, with its center being the center of the quadrat, were listed as to species, the number of each, and their diameters. The purpose of this was to determine whether or not some correlation could be made between the relative amount of cover provided by tree crowns, the direction from which the greatest amount of sunlight hit the quadrat, and the direction in which capsules "pointed."

It should be noted that all the clusters of *B. aphylla* of concern in this paper were found in two rather different woodland situations with respect to cover:

The first type of woodland situation was a densely shaded, mesic condition in which the substrate consisted more of wood humus than of sand. One such quadrat deserves special mention as *Buxbaumia* was represented there in particular abundance. It was located about 75 yards east of the parking area at the Gorge of Carp Creek, across the road and not far to the west of the entrance to the University of Michigan Biological Station. A trunk of *Tsuga canadensis* had apparently fallen and been left to decay undisturbed, thus providing a mound of soft wood humus 6.5 m long and 1 m wide at the middle. The area is now primarily an aspen stand of 50 years' growth, with *Quercus rubra* and *Acer rubrum* also abundant. The layer of *Pteridium aquilinum* was dense except on the mound, where it was sparse and shorter than usual. *Buxbaumia aphylla* was found all along the mound, on both east and west slopes but less so along the center. The plants occurred mostly in dense clusters of at least two or three plants; in one instance an isolated plant was located 1 m away from the nearest cluster. Seventy plants were counted in the representative quadrat taken in this area; two-thirds (46) of them pointed to the southwest. A total of 94 plants occurred outside the quadrat but within the length of the mound; observation showed that 95% of them pointed south to southwest (including the isolated plant).

The second type of woodland situation in which *B. aphylla* was found is characterized by scant cover from tree crowns, rather dry, very sandy soils with little leaf litter, many bits of decaying, often charred wood, and large *Cladonia* mats with scattered areas of *Ceratodon purpureus, Dicranum scoparium, Polytrichum piliferum,* and *P. juniperinum.* In these situations the layer of *Pteridium aquilinum* is sparse and there is obvious evidence of recent disturbances which have prevented a more successful growth of trees and smaller plants. (Two explanations for such disturbances are apparent: the presence of sandy roadways cut through the area and the presence of large

open places in which the soil is blackened and crusty. According to John Cantlon of Michigan State University, it was the practice of loggers to cut trees in such a way that the crowns would fall together in one spot with the trunks radiating outward. With the advent of numerous fires which devastated so much of this area, these piles of tree tops burned hotter than the surrounding area, so hot, in fact, that any living organisms in the soil were killed and the area reduced to the point of succession from bare mineral soil. *B. aphylla* is often found on pieces of charred and/or decaying wood in such areas.) A quadrat taken along a dry, sandy roadway where *B. aphylla* grew at the base of an old stump in open sunlight provides a sharp contrast to the quadrat from a moist habitat on humus described above. In the drier, more disturbed area, large mats of *Cladonia* covered much of the sandy surface together with the mosses mentioned above. In the case of the first quadrat, in the more mesic location, different species of *Cladonia* were abundant, but they were scattered and much smaller, and there was little *Ceratodon* or *Vaccinium*, both of which were abundant in the more xeric, sandy quadrat. Also in the first quadrat, the mound of humus was covered largely by leaf litter, decaying fronds of *Pteridium,* and bits of decaying wood; large tufts of

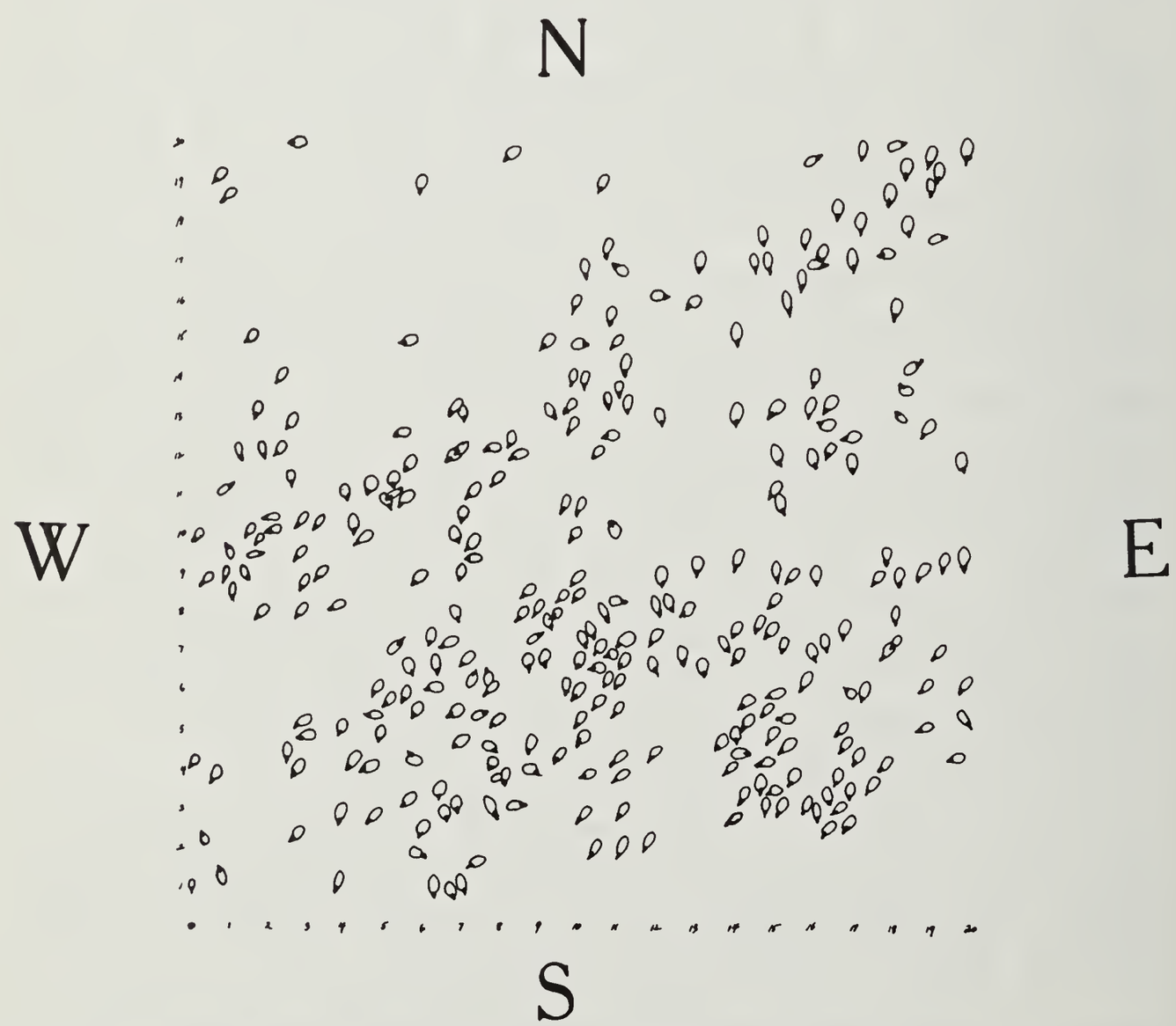

Fig. 1. A summary chart based on the actual positions of 294 capsules of *Buxbaumia aphylla* in 10 quadrats, showing the directional orientation.

Dicranum montanum, D. scoparium, D. flagellare, and *Heterophyllium haldanianum* were present throughout.

Despite the differences exemplified by the two quadrats discussed above, the data from all ten quadrats reveal several important characteristics common to them all. One of the smallest of leafy liverworts, a *Cephaloziella,* which forms a dark crust on the soil, was associated with *Buxbaumia* with a frequency of 100%. (The presence of the crust provides a convenience in finding the Buxbaumias.) Also characteristic were varying amounts of different Cladonias, ranging in size from small squamules to mats covering much of the quadrats. Some of the more common species of *Cladonia* present were *C. uncialis, C. sylvatica, C. chlorophaea, C. cristatella, C. deformis,* and *C. alpestris.* Other mosses were *Polytrichum piliferum, P. juniperinum,* and *Pohlia nutans,* with a frequency of 20%, and *Dicranum scoparium, Ceratodon purpureus, Heterophyllium haldanianum,* with a frequency of 10%. Also with a frequency of 10% were the liverwort *Ptilidium pulcherrimum* and the vascular plants *Pteridium aquilinum* and some species of *Vaccinium.*

The pH of the soil was found to be 4.0 in 70% of the quadrats; other measurements ranged between 4.5 and 5.25. In a radius of 5 m around each quadrat were equal numbers of *Populus grandidentata* and *Quercus rubra; Pinus strobus, Acer rubrum, Pinus banksiana,* and *Populus tremuloides* were present in lesser number.

From the limited data, it is not possible to correlate the cover provided by tree crowns and the abundance of capsules or the direction in which they point. However, the individual maps of quadrats revealed that in instances where one distinct source of shade was obvious, capsules pointed away from it and hence toward a source of greater light intensity. The actual orientation of all capsules found in the ten quadrats is indicated here in a summary map (Fig. 1). Of 294 capsules counted, the directional orientation in percentages is as follows:

southwest	45%	southeast	6%
south	30%	northwest	2%
west	8%	north	1%
east	7%	northeast	1%

Large clusters of *Buxbaumia* were found in both open and shady places. In both situations the direction of the capsules was primarily south to southwest. The only explanation that I can offer is that perhaps by facing south the broad tops of the capsules receive maximum radiation which for the maturing, photosynthetic sporophyte is obviously important, especially in view of the extreme reduction of the leafy gametophyte. The plants are said to be saprophytes, and therefore the use of radiant energy might be questioned, but it should be noted that the sporophytes are abundantly green until maturity and hence at least partially self-nourishing.

ACKNOWLEDGMENTS

My thanks are due to Edwin Phillips and Howard Crum for advice and encouragement.

A RARE *SEPTOBASIDIUM* ON SCALE INSECTS ON *CORNUS* FOUND IN MICHIGAN

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Some of the most interesting fungi are found in those families that have established symbiotic (parasitic?) relationships with insects. On 15 May 1971, one of these fungi, *Septobasidium carestianum* Bres., was found associated with scale insects on *Cornus* in the Stinchfield Woods, Washtenaw County (Fig. 1). A search of the literature failed to find any record of this fungus having been collected in the U.S.A. Couch (1938) reports seven collections on *Chionapsis corni* Cooley on *Cornus stolonifera* Michx. made in Canada near London, Ontario, between 1911 and 1931 by John Dearness. One very small collection was found in the University of Michigan Herbarium, made at Crooked Lake near Dexter in 1943 by L. E. Wehmeyer and A. H. Smith, and which had been identified by John N. Couch. In reply to an inquiry, Dr. Couch very kindly furnished me with four additional records that had come to his attention since 1938. Two were from New York State and two from Canada:

1. Indian Lake, N.Y., collected July ? by Charles H. Peck, and now in the N.Y. State Museum, Albany, N.Y. Annotated by E. A. Burt as "closely resembling *S. carestianum* Bres."
2. Michigan Hollow, south of Ithaca, N.Y., on living branches of *Cornus* sp. Nov. 12 ?, collected by H. S. Jackson.
3. On *Alnus incana* in a swamp north of Mt. Albert, Ontario, 25 Sept. 1936, collected by H. S. Jackson. Univ. of Toronto #9283.
4. On *Viburnum alnifolium,* Forest Rangers School, Duchesnay, Quebec, 3 June 1939, collected by Pomerleau and Couch. Univ. of N.C. #11086.

The genus *Septobasidium* was monographed on a worldwide basis by Couch (1938), who records a total of 41 taxa present in North America: 36 in the U.S.A., one in Canada, and four in Mexico. The genus is most abundant in the tropics. The greatest number of species have been collected in the southeast, while only five species were found in the northern states. The Canadian species reported had, at that time, not been found outside of Ontario. Couch considered that the genus was poorly known because many species are small, and rarely attract the attention of collectors. The species recorded up to that time were often those on commercially important plants, where plant pathologists found them of interest and reported them as disease organisms.

The relationship that exists between these fungi and the scale insects is most interesting, as the fungus is completely dependent on the insect for the nutrients necessary for growth and reproduction. Superficially, the fungus

Fig. 1. *Septobasidium carestianum* covering colonies of *Chionapsis corni* on *Cornus stolonifera* (Harrison 10267). Photo by A. H. Smith, about natural size. The elevated margins of the fungus are supported on pillars of hyphae. The tiny scales are sheltered by the roof of mycelium that develops over them.

appears to be parasitic on the shrub or tree, but it is only the scale insects that feed directly on the host plant. The fungus is connected by haustoria inside the insect, and all nutrients to maintain the fungus must pass through the body of the living scale. The insects are only infected during the very early life of the nymph. The young nymphs, within a few hours of birth, move to a spot on the bark and settle down, after penetrating the bark with their sucking tube. Once suitably established, the healthy insects exude a waxy covering which very quickly forms a protective scale.

In the infected nymphs the fungus, after developing haustoria in the circulatory system, sends out hyphae that grow over the insect in a manner characteristic for the species. In some, this covering forms pillars that expand at the apices to gradually enclose tunnels and chambers that protect both healthy and infected scales. In the more complex forms, the fungal structure may be in layers up to 3 stories high and 1 cm thick, protecting hundreds of scale insects. In simple forms, it may be little more than a hyphal covering for a cluster of insects. The amazing feature of the insect-fungal relationship is that these tunnels and chambers play a vital role in the survival of the insects. They protect the healthy uninfected scales from their natural parasitic enemies, thus aiding in the survival of the species. The infected insects cannot reproduce, and are little more than pumping stations supplying nutrients to the fungus. In regions where scale insects are abundant, the fungal habitations can also be sought out by young nymphs from other colonies, which in turn, settle down to complete their life history in habitations already established.

The early stages of the fungus developing around the scales are sterile until after a covering has been established over the chambers. Then the surface of the covering forms a layer containing probasidia. These in turn, when the weather is rainy or highly humid, become transversely septate basidia, each cell of which produces a basidiospore. In most cases, these bud to produce smaller spores which are the infective bodies adhering to the young nymphs whenever they crawl over the hymenial surface. Some species produce conidia that function in the same manner. Nymphs that hatch or molt during dry weather when no spores are being produced, or those that emerge from tunnels on the extreme margins and do not need to crawl over the spore-producing surface, are rarely infected.

The above is a brief summary of the relationship that exists between species of the genus *Septobasidium* and the scale insects on which they depend. The specialized structures formed by each fungus, and the intricate variations developed with each scale insect, are not mentioned. There are still details to be worked out for many of the species in the genus.

The following is a brief technical description obtained from the Michigan collections. Many measurements are slightly larger than those given by Couch (1938), but were made from fresh material that sporulated freely under moist conditions in a plastic bag.

Septobasidium carestianum Bres. Malpighia 11: 254. 1897.

Fruit body perennial, 0.25-1.0 mm thick, resupinate, in age stratose as a new layer forms on top of the old. Surface smooth, colliculose in age, with crevices from irregular secondary growth. White on extreme margin to a pale buff, drab gray in oldest part; in old fruit body center is watery cinnamon drab. With a thin white arachnoid subiculum, tufted in places (in May), the apices of the tufts expanding and fusing to cover channels and chambers; tufts becoming pillars supporting the covering, white at first, two-year old pillars brownish.

Hymenium developing in upper layer; probasidia pear-shaped, 16 × 8.7 μ forming below the surface in the mycelium; metabasidia produced from probasidia in rainy weather, 43-70 × 5.2-7.0 (mostly 55 × 5.2) μ, transversely septate, four celled; each cell produces one basidiospore which is curved-elliptic 14-20 × 3.5-4.2 μ; sterigmata variable, up to 17 μ long. Cells that have produced spores appear empty. Spores are rare, but metabasidia are abundant when a fruit body is placed in a moist chamber. Spores produced in moisture may either bud or germinate. Metabasidia occasionally have one or two cells with disorganized contents; the ultimate cell is rarely affected, and may be the only cell to produce a spore.

Hyphae of trama 2.5-3.5 μ broad, thick-walled, hyaline; some may be brown in old tissues, no clamps; subiculum and surface layers compact.

Seven insects were removed from the bark from under the fungal covering, crushed, stained in phloxine and examined. One showed the clusters of fungal haustoria as described by Couch (1938).

Habit, habitat, and distribution: Growing over dense colonies of *Chionapsis corni* Cooley on a green-barked clone of *Cornus stolonifera* Michx. Growth rather weak and unhealthy in appearance, in a thicket in a small swamp surrounded by conifers. The largest fungus patch was 11 cm long on a stem 2 cm thick. Many of the fruit bodies were found close to the ground on rooting semiprostrate trunks, while only very few patches were on small upright stems. Usually several patches on one trunk, but never higher than two feet above the ground. Only reported in the U.S.A. from Michigan and New York, and in Canada from London, Ontario, and Duchesnay, Quebec.

Michigan material examined: Harrison 10267, 10268, Washtenaw County, in the University of Michigan Herbarium.

ACKNOWLEDGMENTS

The coccid host was identified through the kindness of Dr. Michael Kosztarab, Professor of Systematic Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia; and the *Cornus* species by Dr. Melinda F. Denton, Department of Botany and Plant Pathology, Michigan State University, East Lansing. It is a pleasure to acknowledge support during the preparation of this paper from NSF Grant G. B. 16969, to A. H. Smith, Director, University of Michigan Herbarium.

REFERENCE

Couch, John N. 1938. The Genus Septobasidium. Univ. of N.C. Press, Chapel Hill. 480 pp.

MICHIGAN PLANTS IN PRINT
New Literature Relating to Michigan Botany

A. MAPS, SOILS, GEOLOGY, CLIMATE

(Bureau of Outdoor Recreation). 1970. Islands of America. U.S. Dep. Interior. 95 pp. $2.00 (Supt. of Documents). [Includes general discussions and tabular data on size and percent development of islands 10 acres and larger in size, including those of the Great Lakes. "Development" refers to private resorts; by a strange twist of definition, agricultural land and "public and quasi-public recreation developments were considered as undeveloped." Text acknowledges "some degree of error" and considers that "these inaccuracies are marginal." Some careless errors and inconsistencies seem more than marginal: Isle Royale is in Michigan, not Wisconsin (p. 70); Isle Royale is mentioned on p. 31 as "the largest" of the Great Lakes islands, but is omitted from the table in App. III which lists islands and acreages; Drummond Island is mentioned on pp. 31 & 32, but is another very large island omitted from App. III.]

Larson, Richard L. 1971. Soil Survey of Macomb County, Michigan. U.S. Dep. Agr. 110 pp. + 36 once-folded map plates + 5 folded tables & indexes. $3.25 (Supt. of Documents). [As in other recent soil surveys, includes complete aerial photographic coverage for the county, at a scale of about 3¼″ = 1 mile, with boundaries of soil types overprinted. For field workers, an invaluable replacement for the 1928 survey of the county.]

Manny, B. A., M. C. Miller, & R. G. Wetzel. 1971. Ultraviolet combustion of dissolved organic nitrogen compounds in lake waters. Limnol. Oceanogr. 16: 71-85. [Includes table of general limnological characteristics of several lakes in Barry and Kalamazoo cos.: Purdy, Cassidy, Wintergreen, Duck, Lawrence, & Gull.]

Strommen, Norton D. 1969. Climatic Summaries of Resort Areas. Isle Royale National Park Michigan. Climatogr. U.S. 21-20-1. 4 pp.

Strommen, Norton D. 1970. Climatic Summaries of Resort Areas. Pictured Rocks National Lakeshore. Climatogr. U.S. 21-20-3. 4 pp.

(U.S. Army Engineer Division). 1971. Water Resources Development by the U.S. Army Corps of Engineers in Michigan. viii + 80 pp. + map. [Includes introduction and descriptions of projects, usually with oblique aerial photo showing the harbor, etc., and surrounding habitat, and often with brief history of construction. Available without charge from Division Engineer, 536 S. Clark St., Chicago, Illinois 60605.]

(U.S. Lake Survey Center). 1971. Great Lakes Water Levels 1860-1970. n. p. [Contains about 180 pages of data from over 50 permanent gages on the Great Lakes and connecting channels. In addition to summaries, tabular records of monthly and annual average water surface elevations are given for each gage "for the period of its existence" according to news release but this is not true. Milwaukee records, for example, begin with 1900 and not 1860. Available for $2.50 from Lake Survey Center, 630 Federal Bldg., Detroit, Michigan 48226.]

Urie, Dean H. 1971. Lake Michigan Snow Squalls Increase Annual Precipitation in the Udell Hills. North Central For. Exp. Sta., U.S. For. Serv. Res. Note NC-120. 4 pp. [Precipitation patterns resulting from topographic influences about 10 miles from Lake Michigan, on an isolated portion of Port Huron moraine in south-central Manistee Co.]

Williams, Ernest B., & Charles R. Eggleton. 1970. Climatic Summaries of Resort Areas. Houghton-Higgins Lake Recreational Area, Michigan. Climatogr. U.S. 21-20-2. 4 pp. [Includes general information and tables of winter and summer maximum and minimum temperatures for 10-day periods. See Strommen, above, for other areas.]

Wood, Warren W. 1970. Chemical Quality of Michigan Streams. U.S. Geol. Surv. Circ. 634. 21 pp. [Generalized maps and detailed table of data from about 200 gaging stations; table includes figures for area drained by each stream as well as discharge (cfs), temperature, and chemical analyses.]

Editorial Notes

The spring campout of the Michigan Botanical Club will be held Memorial Day weekend (Friday evening May 26 to Monday May 29) at one of the most popular sites—the University of Michigan Biological Station on Douglas Lake. Full information on registration, field trip plans, etc., will be sent to all members shortly. See you there!

We are grateful to the Department of Natural Resources for making this month's timely cover picture available. The Natural Resources Commission on January 14 accepted the DNR proposal for wilderness status for much of the Porcupine Mountains State Park, where many Botanical Club members participated in field work in preparation for reports on the natural history values of the Park.

Authors of recent articles who wish to have original art work or manuscripts returned should communicate their wishes to the editor promptly, before the next housecleaning of his files.

The January number (Vol. 11, No. 1) was mailed January 12, 1972.

Errata

Vol. 10, No. 4 (Oct. 1971), p. 207, line 24 from bottom, insert author: By Elbert L. Little, Jr.

Vol. 11, No. 1 (Jan. 1972), p. 46, line 18, insert "never" so end of line will read: Michigan pioneers never used the

Publications of Interest

VASCULAR PLANTS OF OHIO. A Manual for Use in Field and Laboratory. ed. 3. By Clara G. Weishaupt. Kendall/Hunt Plub. Co., Dubuque, Iowa. 1971. 292 pp. $7.50. Slightly revised from the 1968 edition (noted in Mich. Bot. 8: 66. 1969) by insertion of a few additional species (e.g., *Eriochloa contracta* in the Gramineae), correction of some typographical errors, modification of some keys, and the addition (unfortunately after the index, which no longer ends the book) of diagrams and explanations to supplement the glossary and keys to species of some genera of woody plants in winter.

A GUIDE TO OHIO OUTDOOR EDUCATION AREAS. By Ruth W. Melvin. Ohio Department of Natural Resources and Ohio Academy of Science. [1970]. 143 pp., spiral bound. Includes multicolor maps of Ohio's physiography, geology, glacial deposits, and original vegetation; and brief descriptions of about 700 camps, nature preserves, conservation areas, parks, water access sites, aboretums, quarries, etc. Addresses and phone numbers are given for contacts, so this is a most useful directory. A final chart cites acreages and facilities available. There are numerous color photos, but these are not identified and hence it is not always clear which area they illustrate—apparently they belong with the area whose heading *follows* them, not with the area at the end of whose descriptions they appear.

ILLINOIS NATURE PRESERVES. Two-year Report 1969-1970. Illinois Nature Preserves Commission, 819 North Main St., Rockford, Illinois 61103. [1971]. 50 pp. The Illinois nature preserves system was established by the 1963 legislature. The Commission makes recommendations to the Department of Conservation, which spent over $75,000 on land acquisition in the two-year period of this report, which includes itemization of areas dedicated, approved, and under study, as well as descriptions of all 33 areas, totalling 10,724 acres, fully dedicated as Illinois Nature Preserves.

CONTENTS

Studies on Michigan Chysophyceae. I
Daniel E. Wujek & Ralph Hamilton 51

Dale J. Hagenah (1908-1971): An Outstanding Michigan Botanist
Stanley A. Cain & W. H. Wagner, Jr. 60

News of Botanists 66

Wolffia in the Bladders of *Utricularia*:
An "Herbivorous" Plant?
Marvin L. Roberts 67

The Habitat and Orientation of Capsules of *Buxbaumia aphylla*
in the Douglas Lake Region of Michigan
Jennifer Taylor 70

A Rare *Septobasidium* on Scale Insects on *Cornus*
Found in Michigan
K. A. Harrison 74

Michigan Plants in Print 78

Editorial Notes 79

Errata 79

Publications of Interest 79

(On the cover: Escarpment, Lake of the Clouds, and hardwood forest, Porcupine Mountains Wilderness State Park, Ontonagon County, Michigan. Photo by Jon Roethele, Michigan Department of Natural Resources, July 1971.)

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FLORAL PHENOLOGY AT THE MATTHAEI BOTANICAL GARDENS: 1969-1971

Edward L. McWilliams and Louis K. Ludwig
Department of Botany and Matthaei Botanical Gardens,
The University of Michigan, Ann Arbor

Phenology is concerned with the seasonal timing of biological events. Phenological studies are carried out for a variety of reasons. Stearns (1970) has listed more than 25 applications of phenological information including examples from the physical, agricultural, and life sciences. Leopold and Jones (1947) have pointed out that a local phenological record allows one to interpolate, for any given phenological event, a background of contemporaneous events. This type of information can obviously be useful in solving both practical and theoretical problems relating to living organisms. The raw data in this report can provide the basis for several directions of further interpretation and analysis. The present paper summarizes the results of observations of the date of first flowering and the length of the flowering period in a number of vascular plants. A total of 401 species were observed in 1971, 463 in 1970, and 268 in 1969.

Phenological records involving more than 100 species of plants have been made by, among others, Criddle (1927), Jackson (1966), Taylor (1969), Thomas (1963), and Leopold and Jones (1947) to the north (Manitoba), south (Indiana and Tennessee), east (Washington, D.C.), and west (Wisconsin) of Michigan respectively. Pokora (1968) has recently discussed the seasonal changes in a sand prairie in western Michigan. Such records as these plus the present study afford sufficient data for studying the geographical influence on seasonal pattern of phenological change.

STUDY AREA

The Matthaei Botanical Gardens of The University of Michigan is located in Washtenaw Co., Michigan (42° 18′ N. Lat., 83° 41′ W. Long.) approximately five miles northeast of the central campus of the University. The site includes approximately 300 acres of upland forest, floodplain swamp vegetation, seepage bogs, sedge marshes, old fields, dry sandy areas, ponds, and streams. Altitude at the site ranges from 780 feet along Fleming Creek to nearly 820 feet in the upland forest area. (See Fig. 1.)

Most of the Botanical Gardens land is in the valley of Fleming Creek, which enters the area from the northeast. The present Fleming Creek valley lies within a larger valley now filled with glacio-fluvial sands and gravels and more recent alluvium. The outwash deposits were laid down as the last Wisconsin ice sheet in the area, the Cary, retreated into the Lake Erie Basin. Drainage from the Cary ice sheet was blocked to the west by the Outer Defiance moraine when the ice front lay temporarily stationary to the

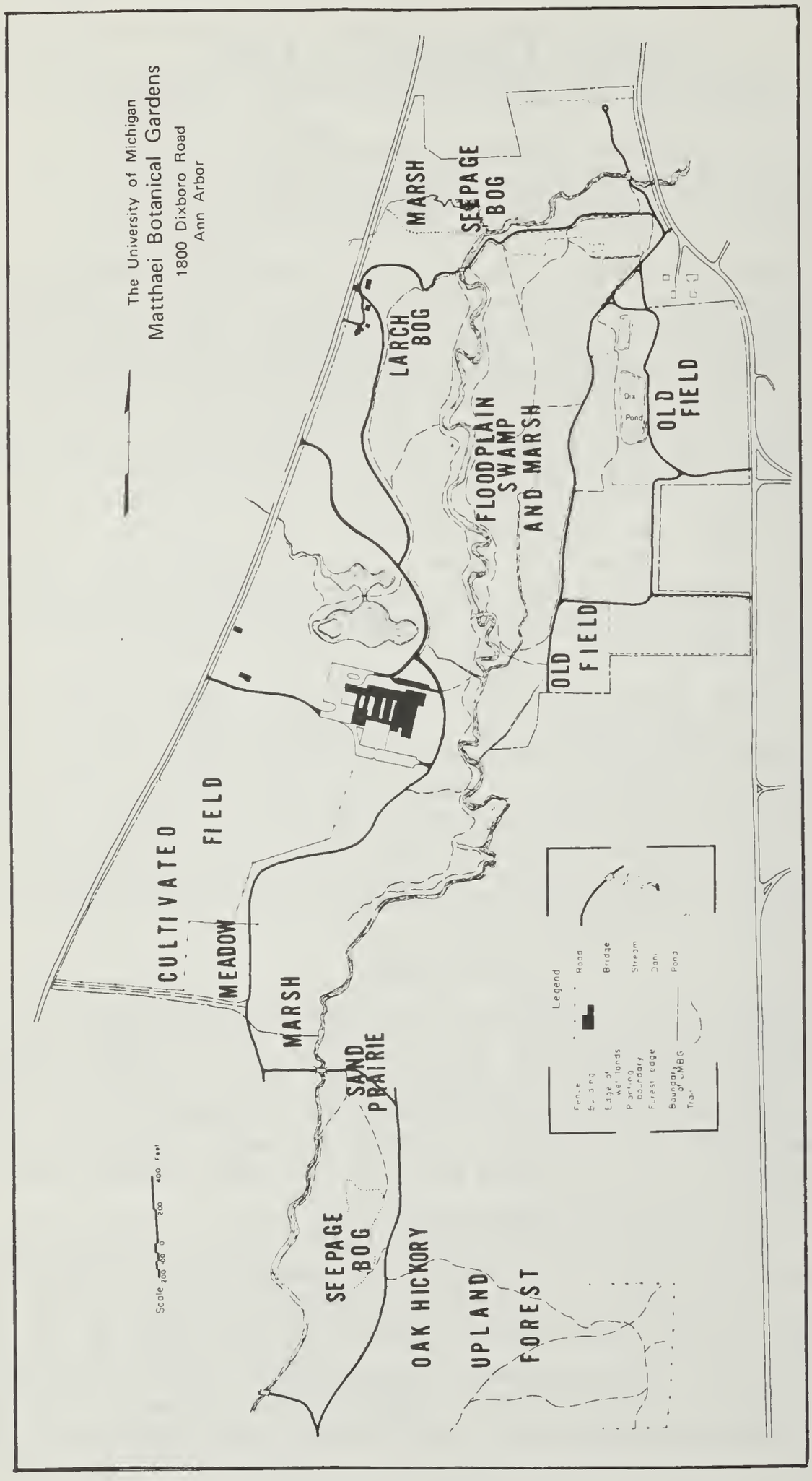

Fig. 1. Map of the Matthaei Botanical Gardens.

east-southeast. The physiography, sediment distribution, and landform classification of the site have been discussed in some detail by Reid (1962).

The natural areas of the Botanical Gardens are used by a number of University classes and several ecological studies have utilized various habitats within the Gardens. Cline (1964) has carried out a detailed investigation of *Scrophularia marilandica* populations in Marsh Hawk Woods. This study included phenological observations of the vegetative development of this species. Radrick Forest has been utilized in studies carried out by Hammitt (1969) and Colwell (1969). Hammitt described the vegetation and soils of several sample plots within the forest, Colwell used the forest as a site for studying ecological specialization and species diversity in arthropods. Several researchers have studied weedy species in disturbed habitats at the Gardens. Gebben (1965) has worked with *Ambrosia artemisiifolia,* Zimmerman (1969) with *Portulaca oleracea,* and McWilliams is currently investigating several *Amaranthus* species.

Ann Arbor, Michigan, which is 5 miles southwest of the Botanical Gardens, has an average frost-free season of 172 days with the average last spring 32° temperature occurring on April 29, and the average first 32° F. temperature occurring on October 18. For Ann Arbor there is a 90% probability of 32° F. temperature or lower occurring on or after April 17 or on or before November 2. During the last 7 years maximum-minimum temperatures and precipitation have been recorded by the staff of the Botanical Gardens.

METHODS

In the present study one or more of each of the major areas of the Gardens was visited at least once every week during the 1969, 1970, and 1971 growing seasons. In this report, all references to seepage bog refer to Radrick Bog and Sinclair Bog, all references to upland forest refer to Radrick Forest, all references to marsh refer to Cummings Marsh and wet, open areas along Parker Brook, Fleming Creek, and Dix Pond. "Old field" refers primarily to Dix and Sanford Fields and the term "weedy area" refers to habitats recently disturbed by man, the latter generally in the area of the cultivated fields. (See Fig. 1.) Many species occur in more than one habitat (stenoecious species). The habitat(s) in which a species was usually recorded is listed in Table 1.

In general, the methods of Leopold and Jones (1947) were followed.

Full expansion of perianth was considered anthesis. In those species without perianths, shedding of pollen was considered anthesis.

The nomenclature of Gleason and Cronquist (1963) is followed. Herbarium specimens were collected for many of the "difficult" or debatable species such as those of *Carex, Salix, Viola, Aster,* and *Crataegus.* These specimens have been filed in the herbarium of the Matthaei Botanical Gardens.

RESULTS AND DISCUSSION

All plants observed in 1970, 1971, and 1969 are listed in Table 1. The flowering dates for 1970 are indicated by a continuous black line, for 1971 by a dashed line, and for 1969 by a dotted line. The first date of flowering is

much sharper than the last date of flowering in most species. In many plants, especially weeds, the last few weeks of flowering are "straggling" and often the species may skip a week and then start flowering again following a rain. The number of new species coming into flower for each week of the growing season is shown in Figure 2. In 1969 there was an obvious bimodal distribution in flowering with a period in mid-June in which very few new species came into flower. In 1970 the same pattern was evident but there was a second slump in flowering in late July. The total number of species in flower during each week of 1969 and 1970 was calculated. In both 1969 and 1970 the peak date was during the last week in July. On July 25, 1969, 157 out of 268 species were in flower or 58.9% of the observed flora. In 1970, on July 31, 203 out of 463 species were in flower or 43.8% of the total observed flora. In 1971, the peak date of flowering was June 18 when 166 out of 401 spp. were in flower or 41.0% of the observed flora.

Phenological events can often be predicted very accurately by means of temperature summations. Temperatures were markedly higher in the spring of 1970 than in the spring of 1969, as might be concluded from the data in Fig. 2 and Table 1. The majority of the spring-flowering species were 5-8 days earlier in 1970 than in 1969. The average temperature recorded for this period (April 3-July 1) was 55.4 degrees in 1970 and only 50.3 degrees in 1969. From July 2 until October 8, the average temperature was slightly lower in 1970 than in 1969. However, the last three weeks of October were much warmer in 1970 than in 1969. The phenological effect of the early onset of

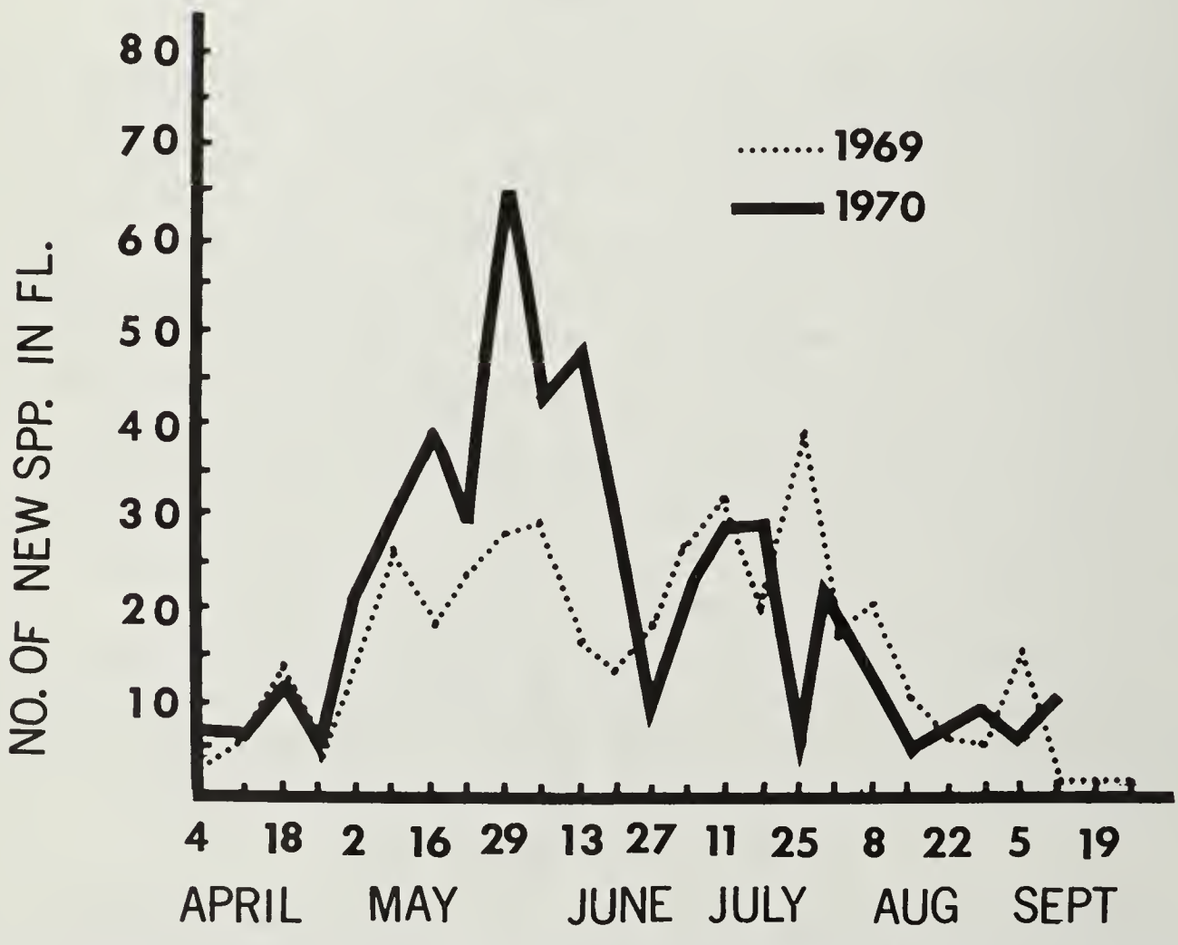

Fig. 2. Number of new species coming into flowering during the 1969 and 1970 growing season.

frost in 1969 is shown by the short flowering period of the late fall flowering species in that year.

The precipitation for the 1971 growing season was well below average for southern Michigan and the effect of moisture stress on the first date of flowering and the length of the flowering period was drastic. As shown in Table 1 many summer flowering species flowered later in 1971 than in the previous two years. Flower abundance diminished markedly in 1970.

By plotting the ratio of new species coming into flower over the number of old species going out of flower we can compute a floral phenological index. The index initially begins very high in the spring before any species have stopped flowering, reaches a peak in mid-May, and declines during the mid- to late June slump (Fig. 2). In 1970 the lowest phenological index was on June 26 (.15); in 1969, the lowest phenological index was on June 20 (.64). The index rises to a second peak in early July and then steadily declines until the date of the first fall frost. The last species began flowering on September 15 in 1971. In 1970 no new species were recorded in flower after September 25, and in 1969 none were noted after September 11. The average date of the appearance of the last new species to flower is September 17 or one month before the average date of the first fall frost. There is no doubt a strong selective pressure against populations of a species that begin flowering too late in the season to mature seeds.

The community and life form to which a species belongs will both have a strong influence on the date of first flowering and the length of the flowering season. Many students of phenology have noted the early flowering of forest species. Trees in general tend to be very early flowering and approximately 90% of the tree species complete their flowering by the first of July. The ephemeral species of the forest floor are also obviously among the earliest spring flowering plants. Sparling (1964, 1967) has discussed the phenology of this group of woodland plants in relation to light intensity and photosynthesis.

Plants of prairies tend to flower in June while marsh plants tend to average somewhat later. Those communities with large numbers of composites in them generally have late flowering dates. Weed communities, largely made up of annuals, have their greatest number of new species coming into anthesis in late June.

One obvious difference between most weeds and native plants is that weedy species have long flowering periods while native plants, with few exceptions, have short or intermediate flowering periods. Early flowering trees and shrubs tend to complete their flowering very quickly, and *Salix* species often complete anthesis in a few days.

An extensive literature exists on both the proximate and ultimate factors affecting date of flowering and length of flowering season (Caprio, 1966; Janzen, 1970). If we assume that date of flowering in a particular species is a product of natural selection, then timing of the pollination and fertilization period should be a major factor in the reproductive strategy of a species (Harper, 1967). The evolutionary implications of floral phenology have been little considered in the literature of plant phenology.

ACKNOWLEDGMENTS

We wish to thank Dr. Warren H. Wagner for his encouragement during this study and Dr. Edward Voss for identification of *Carex* and *Salix* species. Forrest Hartman, Marilyn Bland, Lillian Bloom, and Dr. Terry Sharik assisted us in a number of ways.

Fig. 3. Late July aspect along the banks of Fleming Creek at the Matthaei Botanical Gardens, 1965.

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ABBREVIATIONS IN TABLE 1

Habitat		"Life Form"	
UF	upland forest	A	annual
FP	flood plain	B	biennial
M	marsh	P	perennial herbs
Pr	sand and prairie	T	tree
SB	seepage bog	S	shrub
OF	old field	V	vine
W	weedy		
C	cultivated or escaped		
WT	aquatic		

TABLE 1. Flowering dates at the Matthaei Botanical Gardens for 1970 ——, 1971 - - - - -, and 1969 .....

Acer rubrum T, FP

Acer saccharinum T, FP

Salix rigida S, FP

Salix nigra T, FP

Stellaria media A, W

Symplocarpus foetidus P, M, Wt

Caltha palustris P, M, Wt

Claytonia virginica P, UF

Corylus americana T, UF

Salix fragilis T, FP

Taraxacum officinale P, W

Acer negundo T, FP

Capsella bursa-pastoris B, W

Crocus sp. P, C

Hepatica americana P, UF

Lamium amplexicaule A, W

Populus tremuloides T, Pr

Ranunculus abortivus A, UF

Salix discolor T, FP

Sanguinaria canadensis P, FP

Ulmus americana T, FP

Thlaspi arvense A, W

Viola sororia P, FP, UF

Carex pensylvanica P, UF

Carastium vulgatum A, W

Phlox pilosa P, UF

Viola eriocarpa P, FP

Amelanchier arborea S, UF

Anemone quinquefolia P, SB, FP

Antennaria plantaginifolia P, Pr, OF

Brassica nigra A, W, C

Cardamine douglassii P, FP, M

Cardamine pratensis P, FP, M

Dentaria laciniata P, FP, UF

Fragaria virginiana P, FP, Pr

Lepidium campestre A, W

Ostrya virginiana T, UF

Oxalis stricta A, W, UF

Poa annua A, OF

Ranunculus bulbosus P, FP, M

Ranunculus recurvatus P, FP, M

Rhus aromatica S, PR

Thalictrum dioicum P, FP

Trillium grandiflorum P, UF

Ulmus pumila T, C

Veronica peregrina A, W, OF

Viola canadensis P, UF

Zanthoxylum americanum S, FP, UF, P

Aesculus hippocastanum T, C

Amelanchier spicata S, UF, T

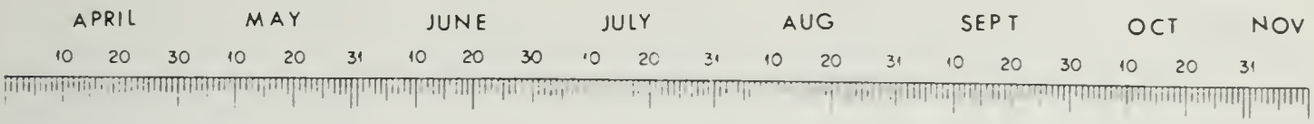
Antennaria neglecta P, OF, Pr

Arabis lyrata B, S, UF

Arisaema triphyllum P, FP

Asarum canadense P, UF

Bromus tectorum A, OF, Pr



Draba nemorosa A, Pr

Equisetum arvense P, FP

Fraxinus americana T, FP, UF

Galium aparine A, FP, UF

Geranium maculatum A, UF, FP

Holosteum umbellatum A, OF

Lithospermum arvense P, Pr, OF

Luzula campestris var. multiflora P, UF

Phlox divaricata P, FP

Polygonum aviculare A, W

Prunus americana T, UF

Ribes americanum S, FP, UF

Ribes cynosbati S, FP

Salix interior S, M

Sassafras albidum T, UF

Senecio aureus P, FP

Smilacina racemosa P, UF, FP

Uvularia sessilifolia P, UF

Viola cucullata P, FP, M

Zizia aurea P, SB

Arabis divaricarpa B, OF, UF

Arabis laevigata B, UF

Aronia prunifolia S, SB

Barbarea vulgaris W, FP, OF

Berberis thunbergii S, C, UF

Comandra umbellata P, OF

Cornus florida T, UF

Crataegus pruinosa T, OF

Erythronium americanum P, FP, UF

Festuca elatior P, FP, OF

Geum triflorum P, UF

Glechoma hederacea P, FP

Lolium perenne P, OF

Lonicera sp. S, C

Mitella diphylla P, FP

Pedicularis canadensis P, UF, SB

Poa pratensis P, OF

Podophyllum peltatum P, UF

Polygala paucifolia P, SB

Polygonatum biflorum P, UF, FP

Prunus serotina T, UF

Prunus virginiana T, UF

Quercus alba T, UF

Ranunculus septentrionalis P, FP, M, SB

Rhamnus alnifolia S, SB

Rumex acetosella A, W

Trillium gleasoni P, UF

Valeriana edulis P, SB, M

Valeriana uliginosa P, SB, M

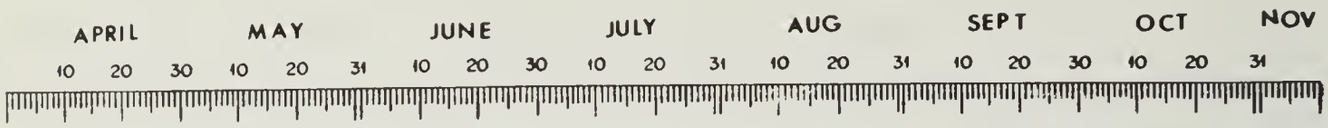
Veronica arvensis A, W

Veronica serpyllifolia P, W

Vicia angustifolia P, OF, UF

Viola conspersa P, UF

Viola pubescens P, UF



Camelina microcarpa A, W, OF

Cornus amomum S, FP

Cornus stolonifera S, FP

Crataegus succulenta T, FP

Cryptotaenia canadensis P, UF

Cypripedium candidum P, SB, W

Eleocharis erythropoda P, M

Erigeron philadelphicus B, W, OF

Hesperis matronalis P, UF, FP

Lepidium virginicum A, OF

Lonicera dioica S, FP

Lupinus perennis P, Pr

Nasturtium officinale R, W

Robinia pseudoacacia T, C

Quercus borealis T, UF

Ribes hirtellum S, SB

Rubus allegheniensis S, FP

Salix serissima S, SB

Saxifraga pensylvanica P, SB

Smilacina stellata P, FP

Smilax herbacea P, FP, UF

Taenidia integerrima P, UF

Valeriana officinalis P, C

Viburnum lentago S, FP

Viburnum dentatum S, C

Allium cernuum P, FP, Pr

Anemone cylindrica P, UF, Pr

Aquilegia canadensis P, UF

Anthemis cotula A, OF

Arisaema dracontium P, FP

Asparagus officinalis P, OF, M

Bromus inermis A, OF

Carex granularis P, M, OF

Carex cephalophora P, UF

Carex rosea P, UW

Chrysanthemum leucanthemum P, W, OF

Cornus racemosa S, FP

Cypripedium calceolus var. parviflorum P, SB

Cypripedium reginae P, SB

Dactylis glomerata P, S, OF

Erigeron annuus A, W

Erigeron pulchellus B, OF

Euonymus europaeus S, C

Galinsoga ciliata A, W

Galium asprellum P, FP

Geum canadense P, M

Heracleum lanatum P, OF

Hierochloë odorata P, M, SB

Hydrophyllum virginianum P, FP

Hypoxis hirsuta P, SB

Iris virginica P, M

Juncus dudleyi P, UF

Juncus tenuis P, UF

Lathyrus ochroleucus P, UF

Lathyrus palustris P, M

Lonicera tatarica S, C

Matricaria chamomilla A, W

Matricaria matricarioides A, W

Medicago lupulina A, W, OF

Medicago sativa P, OF

Mentha arvensis P, M, W

Muhlenbergia schreberi P, W, OF

Pastinaca sativa P, M

Penstemon hirsutus P, OF, S

Plantago lanceolata P, W, OF

Poa compressa P, OF, UF

Phleum pratense P, C, OF

Potentilla anserina P, M, SB

Potentilla argentea P, W, M, SB

Potentilla norvegica A, FP, OF

Potentilla recta P, W, OF

Prunella vulgaris P, FP, M, SB

Ranunculus acris P, W

Senecio obovatus P, UF

Setaria lutescens A, W

Sisymbrium altissimum A, W

Sisymbrium officinale A, OF, W

Sisyrinchium angustifolium A, M, SB

Solanum dulcamara P, FP

Solanum nigrum A, W

Stellaria longifolia P, SB, M

Trifolium hybridum P, OF

Trifolium pratense P, OF

Trifolium repens P, W, OF

Triosteum perfoliatum S, UF

Viburnum acerifolium P, S, UF

Viburnum opulus P, S, FP

Viburnum prunifolium P, S, UF, FP

Vicia villosa P, OF

Vitis riparia P, V, UF

Acalypha rhomboidea A, W

Achillea millefolium P, OF

Actaea alba P, UF

Actaea rubra P, UF

Aegopodium podagraria P, UF

Allium canadense P, UM

Anemone canadensis P, FP

Berteroa incana A, W

Bromus erectus P, Pr

Erigeron strigosus A, UM

Eriophorum viridi-carinatum P, SB

Euphorbia maculata A, Pr

Festuca ovina P, OF

Galium boreale A, FP

Geum rivale P, M

Glyceria striata P, FP, M

Hedeoma hispida A, Pr

Hieracium aurantiacum P, OF

Juncus effusus P, M, SB

Leonurus cardiaca P, W

Lonicera maackii S, C

Malva neglecta A, W

Melilotus officinalis P, OF

Osmorhiza claytoni P, UF

Osmorhiza longistylis P, UF

Physocarpus opulifolius S, FP

Poa palustris A, OF, M

Portulaca oleracea A, W

Rumex crispus P, FP, OF

Rumex orbiculatus P. FP

Sanguisorba canadensis P, SB

Sanicula gregaria P, FP, UF

Sanicula marilandica P, FP, UF

Sedum acre P, C

Sparganum eurycarpum P, M

Stellaria graminea P, FP, M, SB

Thalictrum dasycarpum P, FP

Typha latifolia P, W, M, SB

Verbascum blattaria B, Pr

Agrimonia pubescens P, FP

Apocynum cannabinum P, OF

Blephilia ciliata P, Pr

Bromus ciliatus A, M

Chenopodium album A, W

Chenopodium standleyanum A, W

Cichorum intybus B, OF

Cirsium arvense P, M, OF

Daucus carota A, W

Dianthus armeria B, W

Eragrostis cilianensis A, W

Euonymus atropurpureus S, C

Euphorbia preslii A, W, P

Hemerocallis fulva P, C

Hydrocotyle americana P, SB

Leersia oryzoides P, FP, M

Linaria vulgaris P, C, OF

Lobelia spicata P, W

Lysimachia ciliata P, M, FP

Lysimachia quadrifolia P, UF, Pr

Melilotus alba P, W, OF

Mentha piperita P, C

Nepeta cataria P, OF

Parnassia glauca P, SB

Parthenocissus quinquefolia P, FP, UF

Phalaris arundinacea P, M & SB

Polygonum persicaria A, W

Potentilla fruticosa S, SB, M

Potentilla simplex P, OF

Ranunculus sceleratus A, M

Rosa carolina S, UF

Rosa multiflora S, C

Rosa palustris S, M

Sambucus canadensis S, FP

Saponaria officinalis P, OF

Sium suave P, M

Sparganium americanum P, M, SB

Veronica americana P, W

Agrostis stolonifera var. major P, OF

Asclepias exaltata P, UF

Asclepias incarnata P, M, SB

Asclepias tuberosa P, Pr, OF

Catalpa speciosa T, C

Ceanothus americanus S, UF

Cirsium vulgare B, W

Convolvulus arvensis P, OF, Pr

Convolvulus sepium P, M, FP

Conopholis americana P, UF

Datura stramonium A, W

Euphorbia corollata P, OF, Pr

Hypericum punctatum P, OF

Lobelia kalmii P, M, SB

Lythrum salicaria P, M, Wt

Panicum latifolium P, UF

Plantago major P, OF

Polygonum convolvulus A, OF, Pr, V

Rhus glabra P, OF, S

Rhus radicans P, V, M, UF, FP

Rhus typhina P, OF, S

Scirpus atrovirens P, M, Wt

Silene antirrhina A, Pr

Silene dichotoma A, OF, Pr

Sonchus asper A, OF

Triglochin palustris P, M, SB

Xanthium strumarium A, W

Asclepias syriaca P, OF

Calopogon pulchellus P, SB

Carduus acanthoides B, OF

Carex complanata var. hirsuta P, M

Habenaria hyperborea P, M

Verbascum thapsus B, OF, Pr

Amaranthus albus A, W

Amaranthus graecizans A, W

Amaranthus powellii A, W

Amaranthus retroflexus A, W

Campanula aparinoides P, OF

Campanula rotundifolia P, M

Circaea canadensis P, UF

Cirsium arvense P, OF

Cirsium muticum B, Pr, OF

Epilobium coloratum P, OF

Hypericum perforatum P, M

Laportea canadensis P, FP

Oenothera biennis B, W

Oxybaphus nyctagineus P, Pr

Pastinaca sativa P, M

Pilea pumila A, FP

Rudbeckia hirta B, Pr

Setaria viridis A, W

Spirea alba S, Pr

Urtica dioica P, FP

Verbena urticifolia P, OF, Pr

Arctium minus B, OF

Bidens cernua A, M, SB

Cuscuta gronovii P, V, FP

Desmodium nudiflorum P, UF

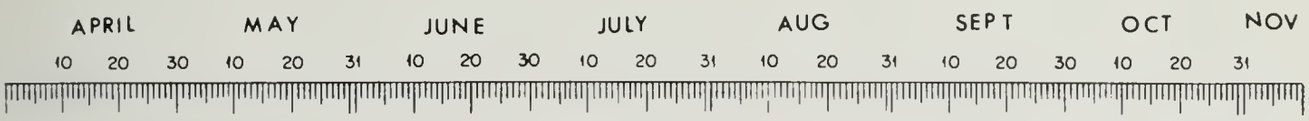
Desmodium paniculatum P, UF

Digitaria sanguinalis A, W

Drosera rotundifolia P, SB

Echinocystis lobata A, V, FP

Funkia subcordata P, C



Impatiens biflora A, FP

Impatiens pallida A, FP

Lycopus americanus P, M, FP

Mimulus ringens P, FP, M, Wt

Monarda fistulosa P, OF

Monotropa uniflora P, UF

Penthorum sedoides P, SB, Wt

Phryma leptostachya P, UF

Physalis longifolia P, FP, OF

Pogonia ophioglossoides P, SB

Polygonum hydropiperoides A, OF

Rudbeckia laciniata P, S, FP

Ruta graveolens P, C

Sonchus uliginosus P, OF

Tanacetum vulgare P, C

Tofieldia glutinosa P, M, SB

Abutilon theophrasti A, W

Agrimonia parviflora P, UF

Amphicarpa bracteata P, FP

Andropogon gerardi P, Pr

Andropogon scoparius P, Pr

Apios americana P, FP

Circaea quadrisulcata P, UF

Desmodium canadense P, UF

Dipsacus sylvestris B, OF

Echinochloa muricata A, M

Eupatorium maculatum P, M

Eupatorium perfoliatum P, M

Eupatorium purpureum P, M

Heliopsis helianthoides P, FP

Hystrix patula P, UF

Lactuca biennis B, FP

Lilium superbum P, SB

Lobelia siphilitica P, M

Lycopus uniflorus P, M, Wt

Panax quinquefolium P, UF

Phragmites communis P, SB

Polygonum achoreum A, FP

Polygonum pensylvanicum A, W

Rudbeckia triloba P, Pr

Silphium terebinthinaceum P, Pr

Solidago canadensis P, OF

Solidago graminifolia P, M

Verbena hastata P, S

Carex bebbii P, M

Polygala verticillata P, Pr

Prenanthes alba P, UF

Sagittaria latifolia P, M, Wt

Alisma subcordatum P, M

Amaranthus hybridus A, W

Apocynum androsaemifolium P, FP

Calamagrostis canadensis P, M

Chondrilla juncea P, Pr

Geum laciniatum P, FP

Lactuca canadensis A, OF

Lobelia inflata A, UF

Lysimachia quadrifolia P, FP

Mollugo verticillata A, W

Panicum capillare A, OF

Panicum virgatum P, Pr

Polygonum cuspidatum P, C

Pycnanthemum virginianum P, FP

Scirpus lineatus P, M

Scrophularia marilandica P, FP

Scutellaria galericulata P, M

Scutellaria lateriflora P, M

Solidago caesia P, UF, FP

Solidago juncea P, M

Veronicastrum virginicum P, UF

Ambrosia artemisiifolia A, W

Ambrosia trifida A, W

Arctium lappa B, W, OF

Bidens frondosa A, M

Chenopodium hybridum A, W

Eragrostis spectabilis P, Pr

Galium triflorum P, FP

Helianthus divaricatus P, OF

Leersia virginica P, M

Liatris spicata P, SB

Physalis heterophylla P, OF

Polygonum virginianum P, FP

Solidago rigida P, S, Pr

Spiranthes cernua P, SB

Aster simplex P, OF

Polygonum lapathifolium A, FP

Aster sagittifolius P, OF

Chelone glabra P, M, FP

Ligustrum ovalifolium S, C

Lobelia cardinalis P, M

Teucrium canadense P, FP

Aster ericoides P, OF

Aster pilosus P, OF

Aster praealtus P, M

Aster puniceus P, M, SB

Erechtites hieracifolia A, OF

Muhlenbergia racemosa P, OF

Solidago gigantea P, OF

Solidago nemoralis P, UF

Solidago patula P, M

Aster lateriflorus P, FP

Aster umbellatus P, OF, FP

Cyperus esculentus A, M

Gentiana crinita P, SB, M

Gentiana procera A or B, M, SB

Solidago riddellii P, SB, M

Aster dumosus P, OF, S

Aster laevis P, OF

Aster novae-angliae P, OF

Gentiana andrewsii P, FP

Solanum carolinense P, FP

Solidago rugosa P, OF

Solidago ohioensis P, M

THE IMPORTANCE OF TURIONS IN THE PROPAGATION OF *MYRIOPHYLLUM EXALBESCENS* (HALORAGIDACEAE) IN DOUGLAS LAKE, MICHIGAN

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Aquatic vascular plants have developed many fascinating adaptations to their environment, e.g., the production of intercellular air spaces or aerenchyma. Some of the submerged hydrophytes can even flower underwater; however, most of these plants must reach the surface of the water in order to flower. Thus, when these plants cannot reach the surface of the water they must reproduce vegetatively if they are to propagate at all. Many different asexual methods of reproduction are used by hydrophytes. One form of vegetative reproduction peculiar to some hydrophytes is the production of turions.

Turions are specialized buds which serve as propagules and as overwintering devices. Turions are defined by Sculthorpe (1967) as ". . . modified types [of overwintering devices], which have no exact terrestrial counterparts, and in which the leaves are specialized in form and quite unlike the normal foliage leaves (e.g., in *Hydrocharis*)." The overwintering device of *Myriophyllum exalbescens* Fernald fits this description (Fig. 1). Its leaves are quite distinct from the normal foliage leaves, being smaller, flatter, and stiffer (Fig. 2) and are appressed along a shortened axis.

In the summer and fall of 1971 while attending the University of Michigan Biological Station, I studied the *M. exalbescens* which occurs in Douglas Lake (Cheboygan County, Michigan) in order to assess the importance of turions in the propagation of the species.

COLLECTION SITES AND METHODS

The sites for the collection of data were: 1) Gull Point, a small spit of sand on the east side of South Fishtail Bay, 2) Hook Point, on the west side of North Fishtail Bay, 3) about one half mile east of the south end of Fairy Island, 4) the east side of the south end of Fairy Island, 5) Maple Bay, about one half mile west of Fairy Island, and 6) about one quarter mile west of Stoney Point (Fig. 3). For the most part, the plants grew in the drop-off region just below the edge of the shoal in about 10 to 20 feet of water. Collections were made by the use of a grappling hook and only plants with both tip and basal parts were counted. The characteristics tabulated were the presence of turion leaves and a U-shaped base of the stem (described below).

RESULTS AND DISCUSSION

Since production of seed could propagate the species, flowering at the collection sites was investigated. Only one plant, at Gull Point, was seen to flower on Douglas Lake, but the inflorescence broke off shortly after it was

Fig. 1. Branch with a turion of *M. exalbescens*. Note the appressed turion leaves and the spreading normal leaves.

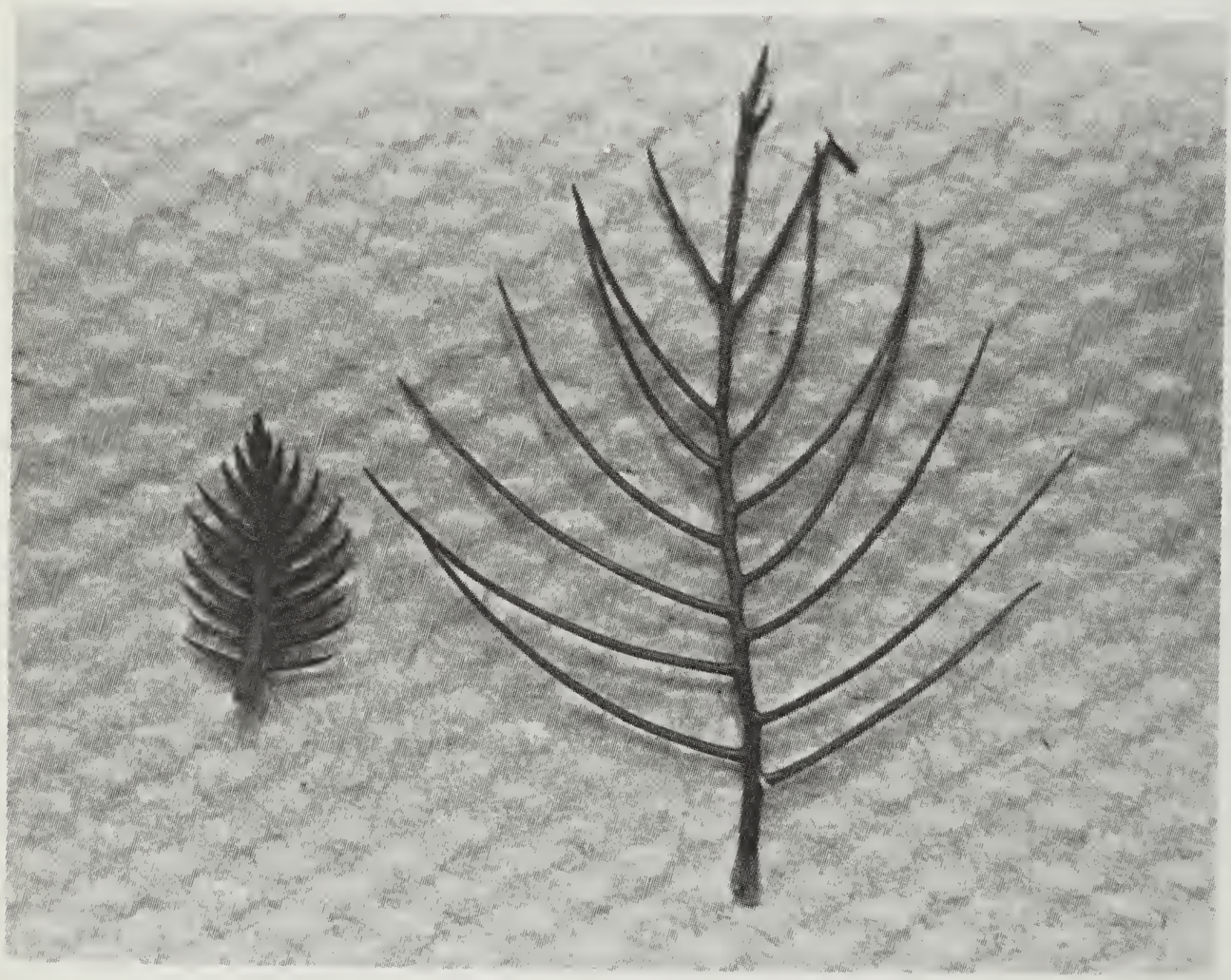

Fig. 2. Turion leaf (left) and normal foliage leaf (right).

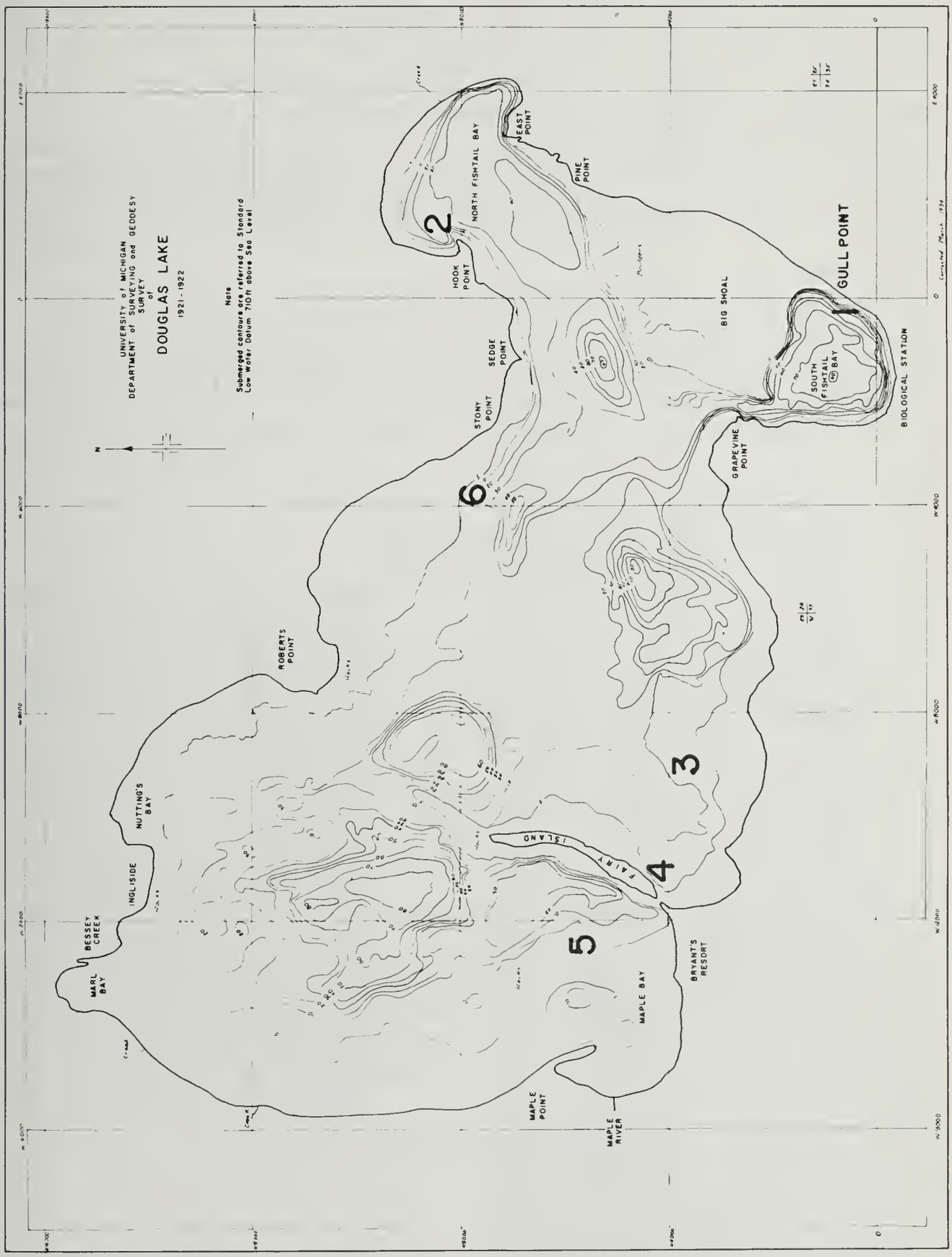

Fig. 3. Map of Douglas Lake showing collection sites. (Horizontal and vertical lines represent 4000-foot intervals.)

discovered on July 13. No fruit was seen. However, *M. exalbescens* in Lancaster Lake and the Black River had been flowering since at least the middle of July. Thus, while plants in other areas were flowering and potentially setting seed, those in Douglas Lake were predominantly not flowering and, therefore, not setting seed. It was possible, then, that this species reproduces largely by turions in Douglas Lake.

A brief description of the germination of a turion of *M. exalbescens* and the characteristics associated with a mature plant which has developed from a turion will help in evaluating the data. These observations were made on turions collected in the fall of the previous year from Hiland Lake (Livingston County, Michigan):

Turions of *M. exalbescens* are formed in the fall and remain attached to the plant until it decays. Part of the parent plant may remain attached for a time and act as a float until that part decays, leaving only the turion, which, being denser than water, sinks to the bottom of the lake. Before the ice has left the lake in the spring, the axis of the turion begins to elongate, preceded by the spreading of the turion leaves and the curving of the axis into a U-shape (Fig. 4). From the base of the U, adventitious roots are formed at the nodes and anchor the turion to the substrate. Normal foliage leaves are produced from the apex soon after germination. Thus, the presence of turion leaves and/or a U-shaped base of the stem indicates that a plant developed from a turion (Fig. 5).

The great majority of plants examined in Douglas Lake had either one or both of these characters present (Table 1). Those few plants which had neither character had stem bases which had either broken or decayed off but which had adventitious roots. Turions were found only on plants collected on the 19th and 20th of October. On the average there were about three turions per plant with over 90% of the plants having at least one turion (Table 2).

During the collection of data on the importance of turions in the propagation of *M. exalbescens,* I noticed that the lower part of the turion did not develop a large aerenchyma in mature plants (Fig. 5) as did the upper part which produces the shoot. I also noted that normal vegetative shoots floated to the surface when uprooted. Further observation of germinating turions revealed that the U-shape of the stem and the development of roots occurred without significant expansion of the arenchyma. It is only after the plant begins active growth that the air spaces develop, thus allowing time for the roots to anchor the plant.

The control of turion formation has received little attention. Sculthorpe (1967) states that induction is controlled by any unfavorable condition or set of conditions. Goebel (1893) and Glück (1906) implicate nutrient deficiency in the initiation of turions of *M. verticillatum* L. However, since *M. exalbescens* is normally rooted and can get much of its nutrient requirements from the substrate (Bristow & Whitcombe, 1971), changes in the nutrients present in the water could be compensated for by the uptake from the roots. This does not mean that the lack of nutrients cannot cause turion formation, but it is unlikely that this initiates turion formation in nature. Recently, Perry (1968) found that turions of *Spirodela polyrhiza* Schleid. could be induced by

short days. While it is not possible to extrapolate from this finding to the formation of turions in *M. exalbescens,* the study of the effect of day length on turion formation might be fruitful.

CONCLUSIONS

The plants of *M. exalbescens* which are present in Douglas Lake were produced to a large extent by turions. The factors which initiate turion formation and germination are not known. However, from this study it is clear that turion formation can be an important means of reproduction for this species.

ACKNOWLEDGMENTS

I wish to acknowledge the advice and encouragement of Dr. Edward G. Voss during the course of this study. Also I wish to thank the directors of the University of Michigan Biological Station, Dr. Frederick K. Sparrow and Dr. David M. Gates, for the use of the facilities. This work was partially supported by National Science Foundation grant number GB-25451.

Fig. 4 (above). Germinating turion of *M. exalbescens*; note root.

Fig. 5 (right). Base of *M. exalbescens* plant showing U-shaped stem and the attached turion leaves.

TABLE 1. Presence of Turion Characteristics at the Base of Mature *M. exalbescens* Plants

Date	Site	Number of plants with turion leaves	Number of plants with U-shaped base	Total number of plants examined
26 July	1	31	36	46
2 August	1	19	19	23
5 August	1	37	40	45
	2	11	19	25
	3	21	19	23
	4	4	4	4
	5	3	1	3
19 Sept.	1	31	35	39
	2	20	22	25
	3	2	39	45
19 & 20	1	0	21	23
October	2	0	19	28
	3	1	45	49
	4	0	1	1
	5	2	7	10
	6	6	22	25

All plants collected on 26 July, 2 August, and 5 August had either turion leaves or a U-shaped base. A few plants collected on 19 September and 19 and 20 October had neither. Those collected on the latter dates which had turion leaves also had U-shaped bases.

TABLE 2. Presence of Turions on Mature Plants of *M. exalbescens* Collected 19-20 Oct. 1971

Site	Number of plants with turions	Total number of plants	Number of turions per plant (range)
1	22	23	2.65 (0-6)
2	28	28	4.7 (1-16)
3	41	49	1.96 (0-5)
4	0	1	0
5	9	10	4.2 (0-9)
6	24	25	1.48 (0-5)
	Total 124	Total 136	Average 2.97

% of plants with turions: 91.2

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Review

AMERICAN VOYAGEUR The Journal of David Bates Douglass. Edited by Sydney W. Jackman and John F. Freeman assisted by Donald S. Rickard and James L. Carter. Northern Michigan University Press, Marquette. 1969. 128 pp. $4.25.

Captain David Bates Douglass (1790-1849) can probably be considered the first person assigned by the U.S. Government to collect plants in Michigan—and the other territories traversed by the Cass Expedition of 1820. Secretary of War Calhoun had authorized this expedition, which hoped to reach the source of the Mississippi. He appointed Henry Rowe Schoolcraft to serve as geologist and mineralogist. Capt. Douglass, of West Point, was to prepare a map and served as botanist. It is fortunate that Douglass' journal is now available in published form. But its editors were apparently unaware that Douglass had sent his specimens to John Torrey, who published an account of them (Am. Jour. Sci. 4: 56-69. 1822), which was accompanied by associated correspondence. (See also review of Schoolcraft's narrative, Mich. Bot. 10: 205. 1971.)

This volume is illustrated with old prints and with maps showing the general route and campsite locations. The expedition left Detroit May 24 for Mackinac Island; left there June 13; and arrived at the western end of Lake Superior on July 5, having examined en route the Grand Sable Dunes and the Pictured Rocks and crossed the Keweenaw Portage. They returned via Wisconsin to Green Bay and Chicago, whence Douglass and Schoolcraft followed the east shore of Lake Michigan back to Mackinac, finally arriving at Detroit September 23 "after an absence of four months and having performed in that time a journey of 4400 miles in birch canoes." Douglass' full observations on the route, so much of which was in Michigan, including notes on plants, water temperature, weather, geological features, and many other topics, make excellent reading for those who love the shores and historic travel routes of the Great Lakes.

Unfortunately there is no reproduction of the original journal or other specimen of Douglass' penmanship. One cannot tell whether the transcription was easy (or as difficult as reading Thoreau!), so there is no way to judge the possible accuracy of this printed account. The work is given an aura of scholarship by copious footnotes and insertions in brackets. In these features, the senior editor assumes a considerable burden by accepting,

in his preface, sole responsibility "for any errors." For this added information is too often erroneous, unnecessary, careless, contradictory, or otherwise less than useful—at least when dealing with biological information. Too many intended explanations seem to result from looking up a term in a dictionary, with no comprehension of whether or not a definition was really applicable to the point at hand. Although perhaps minor in comparison with the basic historical importance of this volume, a few examples of the caliber of the botanical notes should be given for documentation:

Footnotes 42-44 add chaos to an apparently garbled summary of Judge Woodward's botanical system: "Cryptogamous" is not in contrast to "vascular" plants, for the latter include some cryptogams; "grasses and siliceous plants" can hardly mean "grasses and diatoms," for the latter would be among the cryptogams if considered at all; and no plant is known as a "gynosperm." (*Most* scientific names are misspelled: *Crataegus calprodendron,* Liliacious [which does *not* refer to a class], etc.)

Omission of a comma between "white pine" and "tamarac" led to footnote 96 which purports to explain what "pine tamarac" is: "Larix Americana. It is known as the pine larch or lodge pole pine; it looks like a pine but is not." Since *Larix laricina* has not been known as *L. americana* for over half a century, and probably never by the common names cited, the footnote is valueless.

The "pink mockasin flower" is clearly not *Cypripedium calceolus* (misspelled *colceolus* in note 155), which is always yellow, but was undoubtedly *C. acaule,* as could also be judged from the sandy habitat described. On the other hand, the "mockasin flower of a pale rose colour and white" recorded as collected at Keweenaw Point on June 26 rates no footnote, but can be readily identified as *C. reginae,* reported under the synonym *C. spectabile* for that date and locality in the Torrey-Douglass list (1822, p. 67).

The "kinnekineek" [kinnikinick] identified in note 214 as "a variety of Chimophilia [sic] maculata" was *Arctostaphylos uva-ursi*—not *Chimaphila maculata,* which does not grow within hundreds of miles of northern Minnesota. Furthermore, kinnikinick could have been found fully explained ("Smoked by the Indians as a substitute for tobacco") in the Torrey-Douglass list of 1822.

The "turpentine plant" seen at Chicago was probably the composite *Silphium terebinthinaceum,* not the quite unrelated mint *Trichostema dichotomum* as identified in note 272.

The volume has an index, in which words are sometimes spelled a different way from the text (e.g., Scull Rock vs. Skull Rock [Mackinac Island]). Other trivial examples of carelessness: Treatment of "tumuli" (note 36) as singular; consistent use of c. f. for cf.; attempted correction of Douglass' "manulary" to "mammalary" (note 111) [dictionaries support only the spelling "mammillary"]; gratuitous insertion of [Point] in brackets after reference (p. 110) to "the Sleeping Bear," by which Douglass surely meant the particular perched dune on the moraine about 2-3 miles south of Sleeping Bear Point.

Publication of Douglass' narrative is welcome, with his many botanical observations and comments on collecting. It is unfortunate that the work is marred by worthless and misleading footnotes. Why cannot historians seek competent botanical advice if they desire to identify plants—or even copy names correctly out of a manual?

—E. G. V.

MOSSES NEW TO THE STATE OF MICHIGAN

Howard Crum
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Because of long continuity of interest in bryology at the University of Michigan and its Biological Station and also at Michigan State University, the moss flora of Michigan is quite well known. It is always a surprise and a pleasure, therefore, to find something new. Incidental to herbarium studies directed to other purposes, I have recently turned up five records of species additional to the flora and have also confirmed the Michigan occurrence of a species previously reported on the basis of scant and unconvincing documentation.

The moss flora of the state now stands at a total of 370 species, as confirmed by me, a number surprisingly large in view of Michigan's history of geologic vicissitude and human depredation.

Fontinalis dalecarlica BSG.

In water above the Upper Falls of the Tahquamenon River, Luce Co., C. Douthitt, Aug. 1, 1970 (MICH); in seepage, not submerged, at margin of river ca. 100 yards above the falls, same location, W. L. Ellison 117, Aug. 4, 1970 (MICH). —— This species, characterized by long, slender, cuspidate branch tips, grows attached to rocks and usually submerged in swiftly moving water. I have seen specimens from northern and central Europe, and can confirm a broad range of distribution in eastern North America from Newfoundland to Wisconsin and south to Indiana, Tennessee, and Georgia, with outlying occurrences in Alberta and the Yellowknife area of the Canadian Northwest. It has been reported (in Welch's *Monograph of the Fontinalaceae*) from Greenland, Florida, Minnesota, and Saskatchewan, as well.

Fontinalis sphagnifolia (C. M.) Wijk & Marg.

At Delhi Rapids, Huron River, Washtenaw Co., D. McFall, October 16, 1971 (MICH). —— This is the rigid summer growth form, with narrow, lanceolate leaves. The branch leaves are noticeably smaller than the stem leaves and appressed to form long, terete, sharp points which are very conspicuous. The spring form is soft and lax with broad leaves, and the branch tips are not particularly terete. The species is endemic to eastern North America, where it occurs on rocks and submerged in the flowing water of brooks and shallow rivers, from Nova Scotia to Wisconsin and south to Virginia, Kentucky, and Missouri.

Isopterygiopsis muelleriana (Schimp.) Iwats.

On a moist rock ledge, woods near Little Carp Lake, Porcupine Mountains, Ontonagon Co., G. E. Nichols & W. C. Steere, Aug. 20-27, 1935 (DUKE). —— Although this rare (and attractive) moss was included in Darlington's *Mosses of Michigan* on the basis of collections made by Steere in

Keweenaw and Ontonagon Counties, the record cannot be confirmed by specimens at the University of Michigan, where Steere's early collections should be. The species is rare and local in distribution; it grows on moist, shaded, non-calcareous rocks in upland or montane habitats in northern and central Europe, Alaska, and eastern North America from Minnesota to Nova Scotia and south to Arkansas and North Carolina.

Physcomitrella patens (Hedw.) BSG.

On low, moist soil near a drainage ditch, open field, corner of Bemis and Sumter Roads, Wayne Co., S. J. Mazzer 1795, Jan. 1964 (MICH, CAN), 1795B, March 20, 1965 (MICH). —— Widely distributed though minute and ephemeral in occurrence and therefore not often collected. It grows on wet soil, especially in places subject to flooding, at the edges of lakes, ponds, ditches, or rivers; it occurs in Europe and in Eastern North America from Ontario and Quebec south to the Gulf of Mexico.

Tetraplodon mnioides (Hedw.) BSG.

On moist, exposed rock on summit of Silver Mountain, Liard Township, Houghton Co., C. D. Richards 17, May 7, 1949 (MAINE). —— Though sterile, the plants clearly belong to *Tetraplodon* and can be recognized as *T. mnioides* because of oblong-ovate, rather abruptly subulate, entire leaves. The leaves of *T. angustatus* (Hedw.) BSG, which has also been found in the Lake Superior region, both in Ontario and Michigan, are oblong-lanceolate, gradually subulate, and remotely and irregularly serrate at the margins. *Tetraplodon mnioides* is a circumpolar species, known from northern Europe, Siberia, and Japan; it ranges across North America from Alaska to Greenland and south to the Lake Superior region of Ontario and Michigan, Mt. Marcy (New York), Mt. Washington (New Hampshire), New Brunswick, and Newfoundland. It has been collected previously on the dung of various carnivores, on bones and antlers, and on owl pellets. (It is assumed that the label data for Richards' collection can be interpreted as dung or other nitrogenous material on rock.)

Tortula norvegica (Web.) Wahl. ex Lindb.

On a dry limestone boulder at the shore on the south end of Summer Island, Delta Co., N. G. Miller 4755, July 17, 1968 (MICH). —— This species of a western and montane distribution in North America is a fairly well-marked segregate from the variability of the widespread *Tortula ruralis* (Hedw.) Gärtn., Meyer, & Scherb., essentially characterized by a smooth costa which projects as a long, red, shiny, nearly smooth awn. It has not been found elsewhere in eastern North America. Its presence at the north end of Lake Michigan is unexpected, but perhaps, like many calciphiles of wet habitats along the shores of the Great Lakes, explainable in terms of glacial survival in a fringe of vegetation once continuous westward to the Rocky Mountains. —— I previously confirmed the identification as *T. ruralis,* as the collection was reported by Miller and Halbert (Mich Bot. 10: 12. 1971).

CHROMOSOME STUDIES OF SOME MOSSES OF THE DOUGLAS LAKE REGION. II

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During the past twenty-five years chromosome numbers of mosses of various regions have been published in increasing numbers. Studies of North American mosses have been made in California (Vaarama, 1953; Steere et al., 1954), Alaska (Steere, 1954), the Canadian Rockies (Anderson & Crum, 1958), eastern North America (Anderson & Bryan, 1958), Florida (Al-Aish & Anderson, 1960a), Arizona (Al-Aish & Anderson, 1960b), Quebec (Al-Aish & Anderson, 1960c), the southeastern United States (Al-Aish & Anderson, 1961), Washington and Idaho (Ireland, 1963, 1965), the Rocky Mountains (Khanna, 1967), and Iowa (Messmer & Lersten, 1968). The first published report on chromosomes of mosses of the Douglas Lake region (Snider, 1970) involved counts of six species. Counts on the following five species are a continuation of that study.

Collecting methods and meiotic techniques utilized in this study have been described previously (Snider, 1970).

Voucher specimens are deposited in the herbarium of Duke University and the author's personal herbarium.

Thuidium recognitum (Hedw.) Lindb. n = 11 (figs. 1,2). On decaying log, Reese's Bog, Cheboygan Co., Michigan, 25 July 1970, *Snider 1415.* Steere (1954) first reported the number n = 11 for this species in Alaska, with no unusual meiotic behavior occurring. Anderson and Bryan (1958) reported eleven bivalents in the closely related *T. delicatulum,* with one small bivalent characterized by early disjunction. In the Michigan population of *T. recognitum* the number n = 11 was observed; however, a large bivalent consistently underwent early disjunction. In this material the annulus exhibits a very light yellow-green color when meiosis occurs.

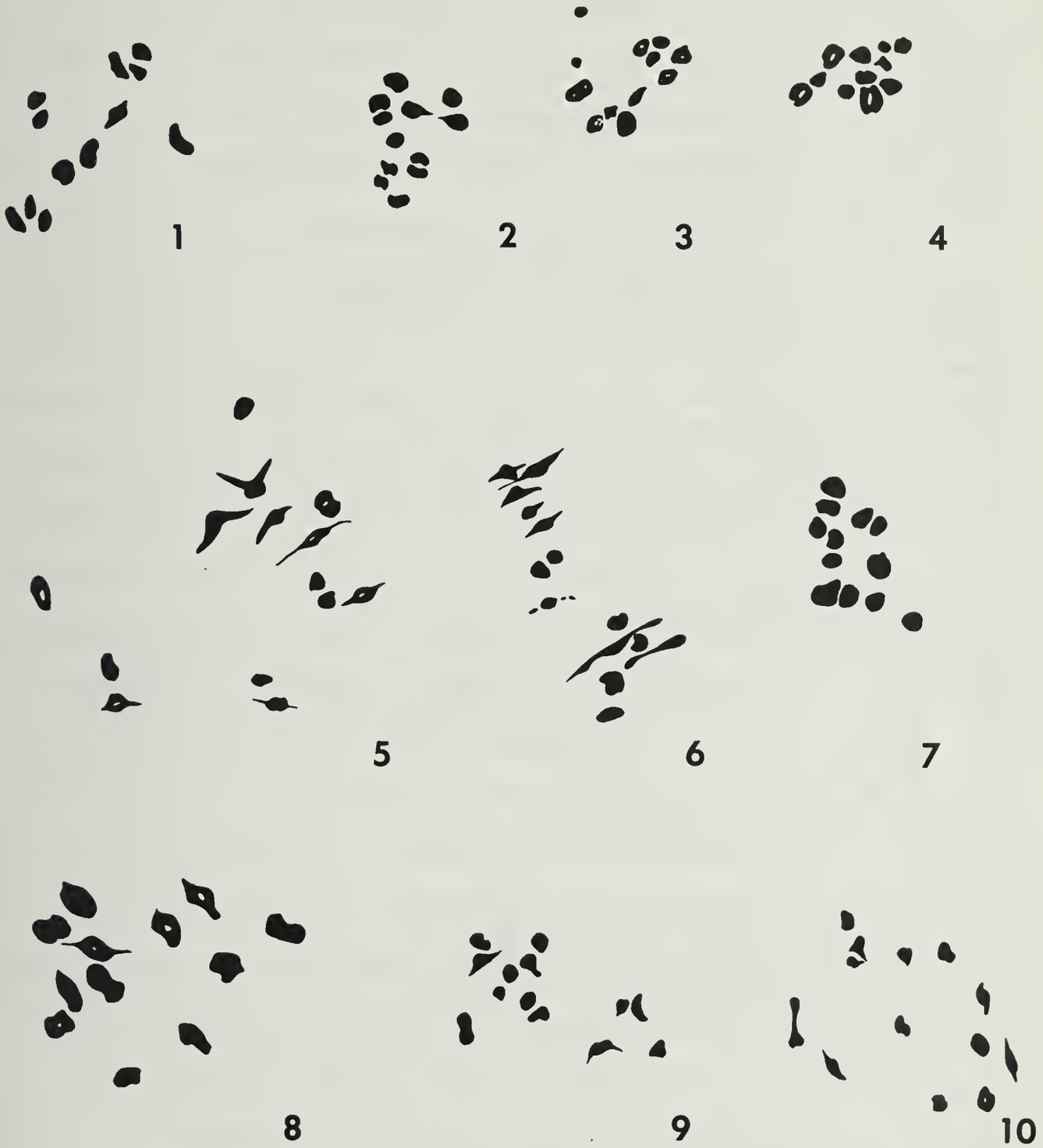
Rhynchostegium serrulatum (Hedw.) Jaeg. & Sauerb. n = 11 (figs. 3,4). On humus, gorge of Carp Creek, Cheboygan Co., Michigan, 13 August 1970, *Snider 1416.* Anderson and Bryan (1958) reported the number n = 9 from Ohio material, and Al-Aish and Anderson (1961) reported the number n = 10 from a North Carolina collection. In both cases a precociously disjoining *m*-bivalent was observed. Although the Michigan count adds yet a different number for this species, the numbers n = 10, n = 10 + m, n = 11, and n = 22 occur frequently throughout the genus. As Al-Aish and Anderson (1961) emphasize, good anaphase figures are needed to resolve many of the numbers reported in the Brachytheciaceae. In the Michigan material the eleven bivalents are comprised of eight pairs of rather uniform size, two large bivalents, and

one smaller *m*-bivalent that usually disjoins early. The bivalents were deeply stained and very distinct, with no apparent irregular meiotic behavior as usually so common in the Brachytheciaceae. Meiosis occurs when the capsule is bright green and the annulus a yellow-brown in color.

Catoscopium nigritum (Hedw.) Brid. n = 14 (figs. 5,6). On sand, along margin of Lake Huron near Evergreen Beach, Presque Isle Co., Michigan, 18 July 1970, *Snider 1417.* Anderson and Crum (1958) published the first counts for this species, n = 14, from Canadian material, reporting that the bivalents stained very poorly, were sticky and diffuse, and often connected with fine threads. Smith and Newton (1968) reported the number n = 13 from a British population of this species. In contrast to the difficulties of Anderson and Crum, the British investigators reported that staining was adequate and the chromosomes were not sticky. In the Michigan population the number n = 14 was observed, with one threadlike chromosome sub-dividing into two or three parts (fig. 6). The chromosomes stained well and were not clumped but the cytoplasm absorbed stain rapidly. The capsule and operculum are a light brown with a tint of green when meiosis occurs.

Dicranum polysetum Sw. n = 12 (figs. 7,8). On soil, aspen woods opposite entrance to the U.M.B.S., Cheboygan Co., Michigan, 29 June 1970, *Snider 1418.* The twelve large bivalents observed in this population agree with reports by Al-Aish and Anderson (1960c) on material from Quebec (as *Dicranum rugosum*). In this genus good preparations are normally difficult to obtain, as has been pointed out by Bryan (1956) and Anderson and Bryan (1958). The chromosomes appear sticky and clump together in groups. By the elimination of heating the preparation following the application of aceto-orcein (Al-Aish & Anderson, 1960c) good preparations were easily obtained. Holmen (1958) reported twelve large bivalents and a small *m*-bivalent in Danish material of this species. No *m*-bivalents were observed in the Michigan material. Yano (1951), observing somatic divisions, reported the occurrence of eleven bivalents in Japanese populations. This problem is discussed in some detail in Al-Aish and Anderson (1960c). The annulus is still green at the time of meiosis, with no trace of yellow or brown color present.

Weissia controversa Hedw. n = 13 (figs. 9,10). On soil along bank of Tahquamenon River above the Upper Tahquamenon Falls, Luce Co., Michigan, 4 August 1970, *Snider 1419.* The thirteen bivalents observed in this population agree with the numerous reports made of this species by Steere et al. (1954) from California, Bryan (1956) and Al-Aish and Anderson (1961) from North Carolina, Anderson and Lemmon (1967) from Ohio, Messmer and Lersten (1968) from Iowa, Khanna (1960) from India, Smith and Newton (1966) from England, and Sannomiya (1955) from Japan. Meiosis is normal and occurs when the annulus exhibits a very light yellow-green color.



Figures 1-10. ca. ×2000. Figs. 1-2. *Thuidium recognitum,* n = 11. Figs. 3-4. *Rhynchostegium serrulatum,* n = 10 + m. Figs. 5-6. *Catoscopium nigritum,* n = 14. Figs. 7-8. *Dicranum polysetum,* n = 12. Figs. 9-10. *Weissia controversa,* n = 13.

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Nature education feature --

FIELD KEY TO SOME COMMON SHRUBS AND VINES OF MICHIGAN

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Keys to Michigan trees in winter condition and summer condition were published in this journal in January 1970 and May 1971, respectively, with emphasis on the common native and cultivated species of the Lower Peninsula. With this short report the authors will have completed efforts at providing "first keys" to those interested in studying our common woody plants who are not familiar with technical terminology. In keeping with the two previous reports we are listing selected references useful in Michigan.

There probably will never be complete agreement on a definition for a shrub as opposed to a tree. All trees pass through a small (shrubby?) stage as they proceed from seedlings to maturity. It is not our purpose to unequivocally delimit shrubs from trees. In fact, we have included certain species which are admittedly trees but which are likely to be encountered in the shrubby condition.

Billington, Cecil. 1949. *Shrubs of Michigan.* 2nd ed. Cranbrook Institute of Science Bulletin 20. 339 pp. $4.50.

Billington's work is the best treatment of the subject. In all, 207 entities are treated, with keys, descriptive text, illustrations in the form of line drawings, and distribution maps. Because several years have elapsed since this book appeared, the distribution maps are not up to date with the results of collectors' efforts, and a few species are included for which no authoritative Michigan record is known. Nevertheless, the number of changes in the shrub flora of Michigan since its publication is insignificant. Its size makes it a handy field guide for the "shrubophile."

Symonds, George W. D. 1963. *The Shrub Identification Book.* M. Barrows & Co., New York. 379 pp. $15.00.

This book contains a visual method for identifying native and naturalized shrubs, vines, and ground cover plants of the eastern United States and Canada. Good quality black and white photographs of 6-11 species appear on each page. The photographs constitute 6 sets of "keys": thorns, leaves, flowers, fruit, twigs, and bark. The reader is advised to begin with key 1 or 2 if possible and continue pictorially toward key 6–bark–until sufficient characters are encountered to insure identification. All information about each species is then assembled on a "master page." This approach is unlike most encountered because keys of the usual "couplet" type are not used and discussions of habitats are not included.

Petrides, George A. 1958. *A Field Guide to Trees and Shrubs.* Houghton Mifflin Co., Boston, 431 pp. $5.95.

This pocket-sized field guide is one of our best references to eastern North American woody plants. It follows the Peterson field guide format and is quite usable by

both the non-professional and professional botanist. In all, 645 species are treated with brief descriptions of key attributes, related species, and general information such as edibility and distribution. Separate keys are provided for plants in winter and summer condition. The line drawings are of good quality and grouped so that related species may be compared easily. The book is divided into five sections. The first treats conifers; the next four, which treat angiosperms, are defined on the basis of leaf arrangement. This reference would make a welcome addition to any general-purpose library.

1. Leaves evergreen, needle-like or scale-like, less than 2.7 mm wide 2
1. Leaves deciduous, their blades expanded, more than 2.7 mm wide 6

2. Leaves covered with woolly hairs . . . . . *Hudsonia tomentosa* (false heather)
2. Leaves without hairs (gymnosperms) 3

3. Leaves whorled, 3 at a node . . . . . *Juniperus communis* (common juniper)
3. Leaves alternate or opposite 4

4. Plants creeping along the ground. . . . . *Juniperus horizontalis* (creeping juniper)
4. Plants erect 5

5. Leaves linear, 1-2 cm long, alternate, their bases continuing along the length of the stem as small ridges . . . . . *Taxus canadensis* (ground-hemlock; yew)
5. Leaves scale-like or awl-shaped or both kinds on the same plant, up to 7 mm long, opposite, their bases not continuous along the stem . . . . . *Juniperus virginiana* (red-cedar)

6. Leaves opposite, sub-opposite, or whorled 7
6. Leaves alternate 44

7. Leaves compound 8
7. Leaves simple 12

8. Leaflets 3 9
8. Leaflets 5-11 10

9. Climbing vine; tendrils present . . . . . *Clematis virginiana* (virgin's bower)
9. Erect shrub; tendrils absent . . . . . *Staphylea trifolia* (bladdernut)

10. Vine; flowers orange, 6-8 cm long . . . . . *Campsis radicans* (trumpet vine)
10. Shrub; flowers white, 3-5 mm wide and long 11

11. Leaflets hairy beneath; pith brown; fruit red . . . . . *Sambucus pubens* (redberry elder)
11. Leaflets hairless below or with few scattered hairs; pith white; fruit purplish-black . . . . . *Sambucus canadensis* (common elder)

12. Branches often spine-tipped; leaves often sub-opposite . . . . . *Rhamnus cathartica* (common buckthorn)
12. Branches not spine-tipped; leaves opposite 13

13. Leaf margins toothed or lobed, the teeth sharp or rounded 14
13. Leaf margins without teeth or lobes 27

14. Vines creeping along the ground; leaves with rounded teeth . . . . . *Linnaea borealis* (twin flower)
14. Shrubs, erect or reclining 15

15. Stems 4-sided 16
15. Stems round or angled but not 4-sided 18

16. Leaves with stalks 1-2 cm long . . . . . *Euonymus atropurpureus* (burning bush)
16. Leaves nearly sessile, the stalks 5 cm long or often shorter 17

17. Plants erect, leaves usually at least twice as long as wide . . . . . *Euonymus americanus* (strawberry bush)
17. Plants prostrate, often rooting at nodes, leaves usually less than twice as long as wide . . . . . *Euonymus obovatus* (creeping wahoo)

18. Stems with ridges just below the nodes . . . . *Diervilla lonicera* (bush honeysuckle)
18. Stems rounded in cross section; ridges absent 19

19. Leaves without lobes 20
19. Leaves lobed. 24

20. Lateral veins each ending in a tooth, the teeth coarse 21
20. Lateral veins not each ending in a tooth, the teeth smaller 22

21. Stipules present; leaf stalks about 7 mm long, rarely to 2 cm long, hairy; hard inner portion of fruit grooved on both sides . . . . . *Viburnum rafinesquianum* (downy arrowwood)
21. Stipules usually lacking; leaf stalks longer, up to 2.5 cm, without hairs or the hairs forked; hard inner portion of fruit grooved on one side only . . . . . *Viburnum dentatum* (arrowwood)

22. Leaf stalks with margin irregularly wavy-winged. . .*Viburnum lentago* (nannyberry)
22. Leaf stalks wingless or the narrow wing straight 23

23. Leaf margins with rounded teeth; flower cluster stalked . . . . . *Viburnum cassinoides* (wild-raisin)
23. Leaf margins with teeth pointed; flower cluster sessile . . . . . .*Viburnum prunifolium* (black-haw)

24. Leaf stalks with glands near base of leaf blade . . . . . *Viburnum opulus* (highbush-cranberry)
24. Leaf stalks without glands 25

25. Lower leaf surface with forked hairs; flower cluster about as broad as long; fruits not winged. . . . . *Viburnum acerifolium* (mapleleaf viburnum)
25. Lower leaf surfaces if hairy, the hairs not forked or branched; flower cluster longer than broad; fruit winged 26

26. Leaves hairy below; leaf teeth coarse; flower cluster erect, its branches again branched . . . . . .*Acer spicatum* (mountain maple)
26. Leaves, at least mature ones, lacking hairs; leaf teeth fine; flower cluster drooping, flowers attached to central axis . . . *Acer pensylvanicum* (striped maple)

27. Plants creeping along the ground 28
27. Plants shrubs or climbing vines 29

28. Leaves 1-2 cm long; flowers white; fruit red . . . *Mitchella repens* (partridge berry)
28. Leaves 3-7 cm long; flowers blue; fruit greenish . . . *Vinca minor* (creeping myrtle)

29. Leaves with rusty scales beneath . . . . . *Shepherdia canadensis* (buffalo-berry)
29. Leaves without scales beneath 30

30. Leaves with small dots, the dots dark or translucent *Hypericum* (St. Johnswort) 31
30. Leaves without dots 32

31. Twigs with 2 ridges; leaves 3-7 cm long, margins not rolled . . . . . *Hypericum prolificum* (common St. Johnswort)
31. Twigs without ridges; leaves 2-4 cm long, the margins often rolled backward . . . . . .*Hypericum kalmianum* (Kalm's St. Johnswort)

32. Leaves sessile; twigs 2-edged . . . . . .*Kalmia polifolia* (swamp laurel)
32. Leaves with stalks; twigs not 2-edged 33

33. Leaves large, 8-15 cm long (sometimes in whorls of 3), their stalks connected by stipules; flowers in dense spherical heads to 3 cm wide . . . . . .*Cephalanthus occidentalis* (buttonbush)
33. Leaves smaller, usually less than 10 cm long, their stalks not connected by stipules; flowers not borne in heads 34

34. Leaves often in whorls of 3; leaf stalks with knobbed hairs . . . . . .*Kalmia angustifolia* (sheep laurel)

34. Leaves usually opposite; leaf stalks without knobbed hairs 35

35. Upper lateral veins curved inward and appearing parallel to midvein *Cornus* (dogwood) 36
35. Upper lateral veins curved or straight but diverging widely from midvein 39

36. Bark of youngest twigs reddish; lower leaf surface with short reclining hairs. . .37
36. Bark of young twigs brown, gray, or yellowish green; leaves with or without hairs 38

37. Twigs covered with hairs at their tips; pith brown; fruit bluish white . . . . . *Cornus purpusi* (silky dogwood)
37. Twigs smooth; pith white; fruit white . . . . . *Cornus stolonifera* (red osier dogwood)

38. Veins 3-4 on each side of leaf; pith often brown . . . . . .*Cornus racemosa* (gray dogwood)
38. Veins 5-8 on each side of leaf; pith white . . . *Cornus rugosa* (roundleaf dogwood)

39. Flowers in clusters of 2-6; petals 5 40
39. Flowers in clusters of more than 6; petals 4 43

40. Leaves 2-3 cm long, hairy below; flowers up to 8 mm long; fruit white. . . . . .*Symphoricarpos albus* (snowberry)
40. Leaves usually longer than 3 cm and hairless or nearly so; flowers usually longer than 8 mm; fruit red, yellow, or green *Lonicera* (honeysuckle) 41

41. Vines; twining or reclining; uppermost leaves united by their bases and encircling the stem . . . . . *Lonicera dioica* (climbing honeysuckle)
41. Shrubs; uppermost leaves separate 42

42. Leaf margins hairy; flowers pale yellow . . . . . *Lonicera canadensis* (Canada honeysuckle)
42. Leaf margins not hairy; flowers pink to white . . . . . .*Lonicera tatarica* (Tartarian honeysuckle)

43. Leaves at least 5 cm long; flowers lilac or white . . . . . *Syringa vulgaris* (lilac)
43. Leaves usually 2-4 cm long; flowers white . . . . . *Ligustrum vulgare* (privet)

44. Plants with thorns or prickles, at least near base of stem 45
44. Plants without thorns or prickles 69

45. Vines climbing by twining stems or slender tendrils *Smilax* (greenbrier) 46
45. Shrubs, erect or leaning but not with tendrils 47

46. Leaves with 5 main veins; prickles stout, green, and scattered . . . . . .*Smilax rotundifolia* (bull brier)
46. Leaves with 7 main veins; prickles slender, dark, and crowded . . . . . *Smilax hispida* (greenbrier)

47. Leaves simple 48
47. Leaves compound 56

48. Leaf stalk with small protuberances near leaf base *Prunus* (cherry; plum) 49
48. Leaf stalk without protuberances 50

49. Teeth of leaves thickened at their tips; sepal margins toothed . . . . . .*Prunus nigra* (Canada plum)
49. Teeth of leaves not thickened; sepal margins without teeth . . . . . *Prunus americana* (wild plum)

50. Thorns longer than 1.5 cm 51
50. Thorns shorter than 1.5 cm 52

51. Thorns blunt-tipped; fruit at least 2 cm wide . . . . . .*Pyrus coronaria* (wild crab apple)
51. Thorns sharp-pointed; fruit less than 2 cm wide . . . . . .*Crataegus* spp. (hawthorn)

52. Leaves longer than wide, not lobed *Berberis* (barberry) 53
52. Leaves about as wide as long, lobed *Ribes* (gooseberry; currant) 54

53. Leaf margins toothed . . . . . *Berberis vulgaris* (common barberry)
53. Leaf margins lacking teeth . . . . . *Berberis thunbergii* (Japanese barberry)

54. Fruit with stiff prickles . . . . . *Ribes cynosbati* (wild gooseberry)
54. Fruit smooth or long-hairy 55

55. Stem densely prickly; fruit with knob-tipped hairs . . . . . .*Ribes lacustre* (bristly black currant)
55. Stem with scattered prickles; fruit smooth . . . . .*Ribes hirtellum* (smooth gooseberry)

56. Leaves doubly compound; thorns weak. . . . . *Aralia hispida* (bristly sarsaparilla)
56. Leaves once compound; thorns rigid 57

57. Leaflets with translucent dots . . . . . .*Zanthoxylum americanum* (prickly-ash)
57. Leaflets without translucent dots. 58

58. Leaflets 5-9 (3 in *Rosa setigera*); stipules united with leaf stalks for at least half their length; flowers at least 3.5 cm wide; fruit resembling a small apple *Rosa* (rose). 59
58. Leaflets 3-5 (rarely 7); stipules scarcely united to leaf stalks; flowers less than 3.5 cm wide; fruit a raspberry or blackberry *Rubus* 64

59. Leaflets 3 . . . . . *Rosa setigera* (prairie rose)
59. Leaflets 5-9 60

60. Prickles decurved 61
60. Prickles straight (or none). 62

61. Prickles present only near regions of leaf attachment; leaves smooth or slightly hairy . . . . . .*Rosa palustris* (swamp rose)
61. Prickles distributed along the stem; leaves densely hairy, the hairs knobbed . . . . . *Rosa eglanteria* (sweet brier)

62. Prickles present mainly at base of stem, upper stem usually unarmed . . . . . *Rosa blanda* (smooth rose)
62. Prickles abundant along the stem 63

63. Flower stalks and floral cup with knobbed hairs; sepals spreading, deciduous in fruit . . . . . .*Rosa carolina* (pasture rose)
63. Flower stalks and floral cup without knobbed hairs; sepals persistent in fruit . . . . . *Rosa acicularis* (prickly rose)

64. Stems horizontal, low-arching or trailing; leaflets usually 3 65
64. Stems erect or high-arching 67

65. Prickles hooked or curved, their bases expanded . . . . . .*Rubus flagellaris* (northern dewberry)
65. Prickles straight or slightly curved, their bases small (or prickles none) 66

66. Stems herbaceous; bristles few to none . . . . . *Rubus pubescens* (dwarf raspberry)
66. Stems woody; bristles many . . . . . *Rubus hispidus* (swamp dewberry)

67. Leaves densely white-hairy below; stems powdery-whitened . . . . . .*Rubus occidentalis* (black raspberry)
67. Leaves hairless below or hairy but hairs not dense and white; stem not powdery-whitened 68

68. Spines with broad bases; fruit black, not hollow, the tip of flower stalk separating with fruit . . . . . *Rubus alleghaniensis* (blackberry)
68. Spines with slender bases; fruit red, hollow, the tip of flower stalk remaining on plant after separation from fruit . . . . . .*Rubus strigosus* (red raspberry)

69. Vines, including plants creeping, trailing, or climbing 70
69. Shrubs; plants erect 86

70. Plants climbing by tendrils or twisting stems 71
70. Plants low, creeping or trailing, tendrils absent 80

71. Leaves compound 72
71. Leaves simple 74

72. Leaflets 3 (POISON) . . . . . *Rhus radicans* (poison-ivy)
72. Leaflets 5 73

73. Leaves shiny above; tendrils without adhesive discs . . . . . *Parthenocissus vitacea* (shiny Virginia creeper)
73. Leaves dull above; tendrils with adhesive discs . . . . . *Parthenocissus quinquefolia* (common Virginia creeper)

74. Plants climbing by tendrils 75
74. Plants climbing by twisting stems; tendrils absent 78

75. Leaves not lobed . . . . . *Smilax herbacea* (carrion-flower)
75. Leaves lobed *Vitis* (grape) 76

76. Mature leaves smooth beneath . . . . . *Vitis riparia* (riverbank grape)
76. Mature leaves hairy beneath 77

77. Leaves rusty-hairy beneath; tendrils and/or flowering stalks often occurring opposite 3 or more successive leaves . . . . . *Vitis labrusca* (fox grape)
77. Leaves whitish beneath; tendrils and/or flowering stalks opposite no more than 2 successive leaves. . . . . *Vitis aestivalis* (summer grape)

78. Leaves about as wide as long, leaf stalks attached to blade above its base . . . . . *Menispermum canadense* (moonseed)
78. Leaves longer than wide 79

79. Leaves unlobed, gradually tapering at base . . . . . *Celastrus scandens* (bittersweet)
79. Leaves often lobed, the base rounded or heart-shaped . . . . . *Solanum dulcamara* (bittersweet nightshade)

80. Leaves compound (go to couplet 72)
80. Leaves simple 81

81. Leaf margins toothed, the teeth small and scattered . . . . . *Gaultheria procumbens* (wintergreen)
81. Leaf margins without teeth 82

82. Leaf stalk 5-30 mm long; stems densely hairy . . . *Epigaea repens* (trailing arbutus)
82. Leaf stalk less than 5 mm long; stems smooth or hairy 83

83. Leaves widest above the middle, 1-3 cm long . . . . *Arctostaphylos uva-ursi* (bearberry)
83. Leaves widest near the middle, averaging less than 1 cm long 84

84. Stems and leaves hairy or bristly. . . . . .*Gaultheria hispidula* (creeping snowberry)
84. Stems and leaves smooth 85

85. Flower stalk bearing 2 green leaf-like bracts above its middle . . . . . *Vaccinum macrocarpon* (large cranberry)
85. Flower stalk bearing 2 red leaf-like bracts near or below its middle . . . . . *Vaccinium oxycoccos* (small cranberry)

86. Leaves compound 87
86. Leaves simple 98

87. Leaflets 3 88
87. Leaflets more than 3 90

88. Terminal leaflet stalked (POISON) . . . . . .*Rhus radicans* (poison-ivy)
88. Terminal leaflet not stalked 89

89. Leaf stalk at least 5 cm long; leaflets with translucent dots; fruit winged . . . . . *Ptelea trifoliata* (wafer-ash)
89. Leaf stalk less than 5 cm long; leaflets not dotted; fruit a reddish berry . . . . . *Rhus aromatica* (aromatic sumac)

90. Leaflets all attached at tip of leaf stalk; flowers bright yellow, 2-3 cm wide . . . . . *Potentilla fruticosa* (shrubby cinquefoil)
90. Leaflets scattered along leaf stalk; flowers if yellowish then less than 2 cm wide 91

91. Stipules attached along base of leaf stalk; leaflets 5-7; flower pink, at least 4 cm wide . . . . . *Rosa blanda* (smooth rose)
91. Stipules absent at leaf base; leaflets 5–50; flower not pink, less than 4 cm wide. . .92

92. Leaflets toothed at least at base 93
92. Leaflets without teeth 95

93. Leaflets toothed only near base; leaves and twigs ill-scented . . . . . *Ailanthus altissima* (tree-of-heaven)
93. Leaflets toothed all along margin 94

94. Twigs hairy . . . . . *Rhus typhina* (staghorn sumac)
94. Twigs smooth . . . . . *Rhus glabra* (smooth sumac)

95. Leaf axis winged between leaflets . . . . . *Rhus copallina* (shining sumac)
95. Leaf axis not winged 96

96. Leaflets 7-13; plants of wet habitats; fruit a white berry, the clusters drooping (POISON) . . . . . *Rhus vernix* (poison sumac)
96. Leaflets 13-51, each less than 4 cm long; fruit a green or brown pod, the clusters borne on upright stalks *Amorpha* 97

97. Leaflets gray-woolly, less than 2 cm long . . . . . *Amorpha canescens* (lead plant)
97. Leaflets sparsely hairy or smooth, more than 2 cm long . . . . . *Amorpha fruticosa* (false indigo)

98. Leaves with main veins palmate (united at leaf base) 99
98. Leaves with main veins pinnate (branching outward from midvein) 106

99. Leaves entire and their bases heart-shaped; fruit a pod. . . . .*Cercis canadensis* (redbud)
99. Leaves toothed or lobed 100

100. Leaves averaging less than 10 cm wide 101
100. Leaves averaging more than 10 cm wide *Rubus* (raspberry; thimbleberry) . .102

101. Leaves not lobed; fruit hard and dry *Ceanothus* 143
101. Leaves lobed; fruit fleshy *Ribes* (currant) 103

102. Upper stems and flower stalks covered with knobbed hairs; flowers white . . . . . *Rubus parviflorus* (thimbleberry)
102. Upper stems and flower stalks smooth; flowers purplish . . . . . *Rubus odoratus* (purple-flowering raspberry)

103. Leaves resin-dotted below; fruit black . . . . . *Ribes americanum* (wild black currant)
103. Leaves not resin-dotted; fruit red 104

104. Stems erect . . . . . *Ribes sativum* (currant)
104. Stems reclining or prostrate 105

105. Leaves ill-scented; fruit with knobbed hairs . . . . .*Ribes glandulosum* (skunk currant)
105. Leaves not ill-scented; fruit smooth. . . . . *Ribes triste* (swamp red currant)

106. Leaves with scales on their lower surfaces . . . . . *Chamaedaphne calyculata* (leather-leaf)
106. Leaves without scales 107

107. Bud scales more than 1 108
107. Bud scales 1 *Salix* (willow) 151

108. Leaf margins without teeth or the teeth obscure (i.e., less than 0.5 mm long) 109
108. Leaf margins wavy or conspicuously toothed 123

109. Leaf margins rolled along the lower surface 110
109. Leaf margins not rolled 111

110. Lower leaf surface covered with woolly rusty hairs . . . . . *Ledum groenlandicum* (Labrador tea)
110. Lower leaf surface with short whitish hairs . . . . . *Andromeda glaucophylla* (bog rosemary)

111. Stems thickest at joints; twigs very flexible, difficult to break . . . . . *Dirca palustris* (leatherwood)
111. Stem joints not noticeably swollen; twigs not extremely flexible 112

112. Leaves averaging at least 12 cm long . . . . . *Asimina triloba* (pawpaw)
112. Leaves less than 12 cm long 113

113. Leaves and twigs fragrant when crushed . . . . . *Lindera benzoin* (spicebush)
113. Leaves and twigs not fragrant 114

114. Leaf stalks averaging greater than 2 cm long . . . . . *Cornus alternifolia* (alternate-leaved dogwood)
114. Leaf stalks averaging less than 2 cm long 115

115. Leaf stalks longer than 3 mm 116
115. Leaf stalks shorter than 3 mm 117

116. Leaves about 3 times as long as wide, bristle-tipped, sometimes minutely toothed near apex . . . . . *Nemopanthus mucronatus* (mountain holly)
116. Leaves about twice as long as wide, the tips pointed but bristle lacking . . . . . *Rhamnus frangula* (glossy buckthorn)

117. Leaves resin-dotted below . . . . . *Gaylussacia baccata* (huckleberry)
117. Leaves not resin-dotted below 118

118. Plants 1-3 meters tall; leaves 4-8 cm long . . . . . *Vaccinium corymbosum* (highbush blueberry)
118. Plants usually less than 0.5 meters tall 119

119. Twigs hairy; lower leaf surface densely hairy . . . . . *Vaccinium myrtilloides* (velvet-leaf blueberry)
119. Twigs smooth, or if hairy the hairs in lines; lower leaf surface if hairy, the hairs on veins only 120

120. Leaves pale green or whitened beneath 121
120. Leaves bright green below 122

121. Twigs with pale whitish film; fruit black 8-12 mm wide . . . . . *Vaccinium brittonii* (low bush blueberry)
121. Twigs without whitish film; fruit blue, 5-8 mm wide . . . . . *Vaccinium vacillans* (upland blueberry)

122. Leaf width 10-15 mm; fruit 7-12 mm wide . . . . . *Vaccinium lamarckii* (low bush blueberry)
122. Leaf width 4-10 mm; fruit 5-7 mm wide . . . . . *Vaccinium angustifolium* (narrow-leaf blueberry)

123. Leaf margins wavy, the teeth large and rounded, at least 2 mm long 124
123. Leaf margins toothed, the teeth pointed or less than 2 mm long 126

124. Leaves fragrant when crushed, resin-dotted below . . . . . *Comptonia peregrina* (sweet-fern)
124. Leaves not fragrant nor resin-dotted below 125

125. Leaves asymmetrical at their base, buds not clustered at tips of twigs . . . . . *Hamamelis virginiana* (witch hazel)
125. Leaves symmetrical at their bases; buds clustered at tips of twig . . . . . *Quercus prinoides* (chinquapin oak)

126. Leaves fragrant when crushed, resin-dotted beneath 127
126. Leaves not fragrant even if resin-dotted 128

127. Leaves toothed mainly near their tips . . . . . *Myrica gale* (sweet gale)
127. Leaves toothed from tip to base. . . . . .*Comptonia peregrina* (sweet fern)

128. Bark of older stems separating in thin strips; leaves often 3-lobed . . . . . .*Physocarpus opulifolius* (ninebark)
128. Bark not separating in thin strips; leaves not 3-lobed 129

129. Leaves with prominent hairs only along upper midvein 130
129. Leaves without hairs on upper midvein 131

130. Twigs and lower leaf surface hairy; fruit 8-10 mm in diameter . . . . . .*Aronia prunifolia* (red chokeberry)
130. Twigs and lower leaf surfaces smooth; fruit 6-8 mm in diameter . . . . . .*Aronia melanocarpa* (black chokeberry)

131. Young twigs hairy at least near leaf attachment areas 132
131. Young twigs not hairy 136

132. Leaf stalks and twigs with knobbed hairs . . . . . *Corylus americana* (hazel)
132. Leaf stalks hairy but without knobbed hairs; twigs if knobbed hairy only so at leaf attachment areas 133

133. Twigs knobbed hairy only at leaf attachment areas; fruit with prominent tubular beak . . . . . *Corylus cornuta* (beaked hazel)
133. Twigs without knobbed hairs; fruit without beak 134

134. Leaves 2-3 cm long, their outline blunt or rounded. . . *Betula pumila* (bog birch)
134. Leaves averaging longer than 3 cm, the tips tapering and pointed. 135

135. Stems with white corky spots (lenticels); leaves doubly toothed, the larger teeth each with several smaller teeth . . . . . *Alnus rugosa* (speckled alder)
135. Stems without white lenticels; leaves with teeth of approximately the same size . . . . . *Spiraea tomentosa* (hardhack)

136. Leaves 2-3 cm long, widest above the middle, their outline blunt or rounded . . . . . *Betula pumila* (bog birch)
136. Leaves if 2-3 cm long the tips with definite points 137

137. Leaves usually with 2 or more small raised areas (glands) at base of blade or apex of leaf stalk; older stems with horizontally elongated areas (lenticels); flowers white or pink, averaging at least 1 cm wide *Prunus* (cherry, plum) 138
137. Leaves without glands; lenticels not represented by horizontal lines; flowers if white or pink, less than 1 cm wide 141

138. Leaves widest above middle, at least 3-6 times as long as wide . . . . . *Prunus pumila* (sand cherry)
138. Leaves usually widest at or below the middle, less than 3 times as long as wide 139

139. Leaf teeth thickened (glandular) at their tips or glands located between teeth . . . 140
139. Leaf teeth sharp, of same texture as blade, glands none 141

140. Glands of leaf teeth located at their tips; stone flattened . . . . . *Prunus nigra* (Canada plum)
140. Glands near base of each tooth; stone spherical. . . . . .*Prunus pensylvanica* (pin cherry)

141. Leaf stalks with glands at their tips; flower stalks arising from an elongate axis; fruit with spherical stone . . . . . *Prunus virginiana* (choke cherry)
141. Leaf stalks not glandular; flower stalks arising from a common point; fruit with flattened stone; stems often spiny. . . . . *Prunus americana* (wild plum)

142. Leaves with 3 principal veins from base *Ceanothus* (New Jersey tea) 143
142. Leaves with 1 midvein 144

143. Leaves widest below the middle; flower clusters originating at points of leaf attachment . . . . . *Ceanothus americanus* (New Jersey tea)
143. Leaves widest at the middle; flower clusters at tips of branches . . . . . *Ceanothus ovatus* (narrowleaf New Jersey tea)

144. Leaf stalks up to 5 mm long . . . . . *Spiraea alba* (meadow-sweet)
144. Leaf stalks longer than 5 mm 145

145. Buds often 2 in leaf axils; leaf scar surrounding 1 (vein) scar. . . . . *Ilex verticillata* (winterberry)
145. Buds 1 in each leaf axil; leaf scars with more than 1 vein scar 146

146. Leaf teeth glandular-thickened at their tips; stems often ending in spines; flowers greenish *Rhamnus* (buckthorn). 147
146. Leaf teeth not glandular-thickened; stems without spines, flowers white or pink *Amelanchier* (serviceberry; shadbush) 148

147. Leaves (and branches) often opposite, lateral veins 3 on each side; fruit with 4 stones. . . . . *Rhamnus cathartica* (European buckthorn)
147. Leaves alternate, with more than 3 lateral veins per side; fruit with 3 stones . . . . . *Rhamnus alnifolia* (alder buckthorn)

148. Top of ovary densely woolly 149
148. Top of ovary hairless 150

149. Leaves at time of flowering barely open, densely woolly; flower stalks hairy, 0.5-2.5 cm long . . . . . *Amelanchier arborea* (downy serviceberry)
149. Leaves at time of flowering about half grown, almost hairless; flower stalks not hairy, 2.5-5 cm long. . . . . *Amelanchier laevis* (allegheny serviceberry)

150. Shrubs less than 2 meters tall; leaf teeth about twice as many as veins; petals 7-9 mm long . . . . . *Amelanchier spicata* (low serviceberry)
150. Shrubs 2-6 meters tall; teeth fewer than twice the number of veins; petals 11-22 mm long . . . . . *Amelanchier sanguinea* (roundleaf serviceberry)

151. Leaves green on both sides (if covered with long hairs then green beneath hairs). . 152
151. Leaves whitened or pale green beneath 157

152. Leaf margin with distantly spaced small teeth; leaf linear, averaging 10-20 times longer than wide . . . . . *Salix interior* (sandbar willow)
152. Leaf margin with closely spaced teeth; leaves less than 8 times longer than wide 153

153. Leaf averaging less than 1.5 cm wide, 6-10 times as long as wide (tree). . . . . *Salix nigra* (black willow)
153. Leaf averaging more than 1.5 cm wide, less than 6 times as long as wide 154

154. Leaf with long silky hairs on both sides (green beneath hairs). . . . . *Salix cordata* (furry willow)
154. Leaf hairless above 155

155. Leaf dull (not shiny) above; leaf stalk without glands . . *Salix rigida* (heartleaf willow)
155. Leaf shiny above; leaf stalk with 2 or more glands near base of blade 156

156. Leaf shiny below, tip long and narrow; stipules present . . . . . *Salix lucida* (shining willow)
156. Leaf not shiny below, tip broader. stipules none . . . . . *Salix serissima* (autumn willow)

157. Leaves sub-opposite, bluish-green below; leaf stalk less than 2 mm long . . . . . *Salix purpurea* (purple willow)
157. Leaves alternate 158

158. Leaf margin entire or with inconspicuous teeth. 158
158. Leaf margin toothed, the teeth evenly spaced 163

159. Mature leaf hairless below except possibly on veins 160
159. Mature leaf with short woolly hairs below (occasionally less so in *Salix humilis*); lower surface wrinkled 161

160. Leaf oblong, the tip usually rounded, 2.5-5 cm long; plants of bogs . . . . . *Salix pedicellaris* (bog willow)
160. Leaf usually broadest above middle, the tip pointed, 5-10 cm long; plants of lowlands . . . . . *Salix discolor* (pussy willow)

161. Leaf 7-15 times as long as wide (midvein sunken above) . . . . . *Salix candida* (hoary willow)
161. Leaf less than 7 times as long as wide (veins prominent below) 162

162. Leaf margin entire (sometimes wavy); midvein sunken above; stipules none or inconspicuous; plants of lowlands . . . . . *Salix bebbiana* (Bebb willow)
162. Leaf margin with inconspicuous teeth; midvein not sunken above; stipules conspicuous; plants of dry uplands . . . . . *Salix humilis* (prairie willow)

163. Leaf stalk glandular near apex (glands obscure in *S. alba*) 164
163. Leaf *stalk* not glandular 167

164. Leaf shiny above . . . . . *Salix serissima* (autumn willow)
164. Leaf not shiny above (trees) 165

165. Branchlets drooping, slender, not brittle . . . . . *Salix babylonica* (weeping willow)
165. Branchlets not drooping, stout and brittle 166

166. Leaves with 7-10 teeth per cm, the teeth less than 0.4 mm deep . . . . . *Salix alba* (white willow)
166. Leaves with 4-6 teeth per cm, the teeth more than 0.4 mm deep . . . . . *Salix fragilis* (fragile willow)

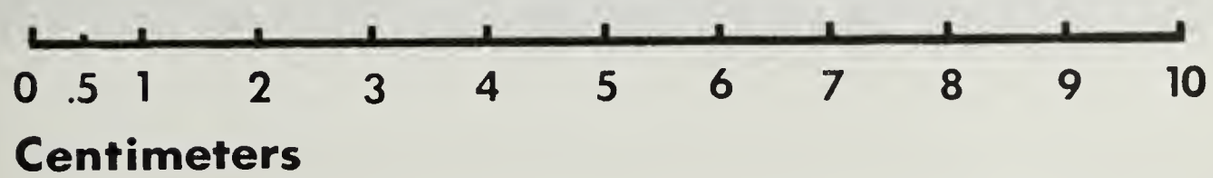
167. Leaves hairless on both sides 168
167. Leaves at least slightly hairy on both sides 170

168. Leaves broadest at middle, averaging 5-10 mm wide . . . . . *Salix petiolaris* (slender willow)
168. Leaves not broadest at middle, averaging 15-30 mm wide 169

169. Leaf stalk stout; 3-6 teeth per cm; leaf tip blunt-pointed; shrub of sand dunes . . . . . *Salix glaucophylloides* (blueleaf willow)
169. Leaf stalk thin; 7-12 teeth per cm; leaf tip long and narrow; shrub or small tree of lowlands . . . . . *Salix amygdaloides* (peachleaf willow)

170. Lower leaf surface with some rusty hairs. . *Salix subsericea* (false silky willow)
170. Lower leaf surface with only light-colored hairs 171

171. Leaf tapering at base; stipules deciduous . . . . . *Salix sericea* (silky willow)
171. Leaf rounded at base; stipules persistent . . . . . *Salix rigida* (heartleaf willow)



WHOSE FIGHT WAS THE PRESERVATION OF NATURE?

Upper photo: Antrim County, Michigan, virgin white pine on property of the David Ward estate, T29N, R5W, sec. 11. Spring of 1905. Photographer: Monte Laur, of Gaylord. Driver of team: Alanzo A. Crego, of Gaylord; seated in back: Fred Smith, cruiser, and Louis F. Smith (with cap), of Otsego Lake.

Lower photo: the same spot, 1959.

ONE NATURAL AREA–PAST AND PRESENT

The photographs on the two preceding pages and the following data were made available to James R. Wells and Paul W. Thompson of the Cranbrook Institute of Science by T. E. Daw, Chief of the Forestry Division, Michigan Department of Natural Resources, Lansing. Although the photographs have appeared before in various DNR publications, we thought them worth sharing with readers as constant reminders that each of us has a continuing duty in the fight to preserve examples of our natural heritage.

The 1905 photograph was presented to the Conservation Commission in 1958 by Myrtle Crego, widow of Alanzo A. Crego, the driver. Louis F. Smith (in the back seat) wrote of the road and timber in 1958:

"The road ran for miles through pine, hemlock, and hardwood timber and emerged on a township road in Hayes Township about seven miles southwest of Gaylord. This pine cut an average of between nine and ten sixteen foot logs per tree. General d.b.h. at this site was forty to forty-four inches. The scale, according to my father, who had logged many millions of similar timber, would be about two and one-half million bd. ft. per forty acres. He said that individual good 'forties' often produced three million bd. ft. and upward. . . .

"This large tract of pine . . . had no takers in the first big rush to buy northern pine because it stood too far from drivable water and main line railroads. Mr. Ward, foreseeing rail logging, purchased a large area and built the 'Detroit & Charlevoix' railroad from Frederic on the Michigan Central to East Jordan on the south arm of Pine Lake, now known as Lake Charlevoix, crossing the Grand Rapids and Indiana (the Pennsylvania) at Alba. This gave him three alternate shipping routes, two railroads and the Great Lakes. . . . He built the mill and town of Deward. This was shut down for a time, but opened after his death, reportedly by the terms of his will that called for the mill to run for ten years before the estate could be divided. . . .

"In the woods the timber fallers carried, besides their usual tools, a shovel and grubhoes. They hewed the large roots down to ground level, digging out the earth between them, and cut the tree as nearly as possible at ground level. While this cost more than the usual method, it gained up to 500 bd. ft. or more of clear lumber per tree. It also saved a lot of log roads as the big wheels in summer and sleighs in winter would go over the stumps instead of digging or blowing them out. . . . I visited the mill in 1908 or 1909 and saw it in operation. At that time they were putting out a lot of 3 × 12″ clear pine. . . . Prices ranged up to $200 per thousand for this grade.

"In general the hardwood and hemlock stands north from the line of Grayling were about one-half of the height of the pine. Usually the maple cut four 16 ft. or three 16 and two 12 ft. logs per tree up to the first big limbs. . . . What was considered good timber cut from 500 to 600 M per forty in mixed stands of these species. A mixture of beech cut the totals, elm increased it considerably."

The second photograph, taken in 1959, is keyed to the portion of a track junction shown at the lower right corner, although the railroad was removed.

Editorial Notes

Remember the spring campout of the Michigan Botanical Club at the University of Michigan Biological Station on Douglas Lake, May 26-29. Field trips to Raber Fossil beds (Chippewa Co.), Wilderness State Park, Lake Shore Drive, and elsewhere. An evening of superb color slides by Bernard Horne, of Jackson. Astronomical and gastronomical surprises!

We welcome to the Editorial Board this spring three new members: Dr. Helen V. Smith (University of Michigan), Dr. John H. Beaman (Michigan State University), and Dr. Ronald L. Stuckey (Ohio State University). Retiring after two or more terms of two years each, and with the thanks of the editor, are three members: Dr. Virginia L. Bailey (Detroit Institute of Technology), Dr. Richard Brewer (Western Michigan University), and Dr. A. H. Smith (University of Michigan).

Beginning January 1, 1973, the price for back issues will be a uniform $3.00 per volume. (The first five volumes have been listed at $2.00 per volume.) Those contemplating ordering complete sets may do so for the remainder of this year at the old price. See inside front cover for details.

The handsome cover photo for this issue appeared previously in an article in the *Ontario Naturalist,* June 1971, and we are grateful to Paul Catling for making it available. He observes that the station is one of three known on the escarpment side of the Bruce Peninsula. The plants grew near the Georgian Bay shore where there was seepage of water over mossy ledges among huge dolomite boulders. A local sedge, *Carex concinna,* was associated with butterwort at this cool site. It, too, is a boreal species (both range south in Michigan to the Straits of Mackinac and can be seen at the campout this spring).

The March number (Vol. 11, No. 2) was mailed March 2, 1972.

Erratum

Vol. 11, No. 1 (Jan. 1972), p. 27, lines 8 and 12 from bottom: for "Poideae" read Pooideae.

First International Congress of Systematic and Evolutionary Biology (ICSEB)

The International Association for Plant Taxonomy and the Society of Systematic Zoology are organizing the First International Congress of Systematic and Evolutionary Biology, which will convene on the campus of the University of Colorado, Boulder, August 4-11, 1973. This inaugural meeting of a new series of international congresses will provide a common meeting ground for scientists devoted to study of the diversity of organisms. The program will consist of two plenary sessions and 18 half-day symposia which will cover broad botanical and zoological interdisciplinary themes. Long-range field trips are scheduled before and after the Congress and several one-day trips will be held during the meetings. The diversity of ecological situations in the surrounding countryside makes Colorado one of the most attractive sites in North America, both esthetically and scientifically.

Persons interested in receiving the ICSEB circular with further information should write promptly to Dr. Robert W. Pennak, Department of Biology, University of Colorado, Boulder, Colorado 80302.

CONTENTS

Floral Phenology at the Matthaei Botanical Gardens: 1969-1971
Edward L. McWilliams & Louis K. Ludwig 83

The Importance of Turions in the Propagation of *Myriophyllum exalbescens* (Haloragidaceae) in Douglas Lake, Michigan
James A. Weber 115

Review—American Voyageur 121

Mosses New to the State of Michigan
Howard Crum 123

Chromosome Studies of Some Mosses of the Douglas Lake Region. II
Jerry A. Snider 125

Nature Education Feature—
Field Key to Some Common Shrubs and Vines of Michigan
James R. Wells & Paul W. Thompson 129

Whose Fight Was the Preservation of Nature? 140

Editorial Notes 143

Erratum 143

First International Congress of Systematic and Evolutionary Biology 143

(On the cover: Butterwort (Pinguicula vulgaris), *an insectivorous plant photographed June 27, 1970, at Driftwood Cove, Bruce Peninsula, Ontario, by Paul M. Catling.)*

33
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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors should be guided by "Information for Authors" (Vol. 9, p. 62; copies available from the editor).

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THE GENUS *HELVELLA* IN MICHIGAN

Nancy Smith Weber
Herbarium, The University of Michigan, Ann Arbor

Helvella as a genus of Discomycetes has been recognized since Linnaeus (1737) proposed the name *Elvela.* However, a stable generic concept emerged slowly. The generic delimitations proposed by Boudier and Quélet illustrate the extremes in generic concepts of *Helvella.* Boudier (1907) limited *Helvella* to stipitate operculate Discomycetes with a mitrate to saddle-shaped apothecium, a ribbed or terete stipe, and guttulate spores. Boudier's classification was also employed by Berthet (1964), Moser (1963), and Dennis (1968). In contrast, Quélet (1886) included both stipitate-cupulate species and those with a lobed apothecium in *Helvella.* Nannfeldt (1937) refined Quélet's concept by excluding *Gyromitra*-like species from the genus. His concept is employed here as well as by Dissing (1964, 1966), Dissing and Lange (1967), Dissing and Nannfeldt (1966), and Eckblad (1968).

The *Helvella* flora of North America is poorly known. Only a few surveys of the genus have been published. The most notable ones include Anderson and Ickis (1921), Burt (1899), Gomez and Herrera (1965), Groves and Hoare (1953), Henry (1947), Kempton and Wells (1970), Seaver (1928), and Underwood (1896). None of these deal adequately with the diversity of Helvellas found in Michigan. This paper represents a beginning on the problem of documenting the diversity in *Helvella* for the Great Lakes region.

MATERIALS AND METHODS

Collecting techniques were those in common use for fleshy fungi. Some specimens were dried using standard mushroom driers (Smith, 1947) and others were prepared using the silica gel technique (Hoseney, 1963).

Dried herbarium material was prepared for study as follows: a piece of tissue, either of the apothecium with the margin intact, or of the stipe, was moistened with 95% ETOH and soaked until soft in a few drops of distilled water on a microslide. The tissue was blotted and free-hand sections were made with a single-edge razor. Melzer's reagent, 2.5% KOH, and Poirrier's blue in 85% lactic acid were used to mount sections for examination. Sections mounted in lactic acid were gently heated over an alcohol lamp. The descriptions are based on the appearance of sections mounted in KOH or water. Spore measurements were made from spores discharged by intact apothecia onto a microslide or from spores released by pieces of apothecia when they were soaking in water in preparation for the study of dried material.

HABITAT AND SEASONAL OCCURRENCE

Since the *Helvella* floras of southwestern Michigan and the western Upper Peninsula are still relatively poorly known, a detailed discussion of the

distribution of the genus is not possible at present. However, some observations on habitat and seasonal occurrence can be made.

The span of time within a growing season during which a species typically fruits may be a matter of only weeks or as long as several months (Table 1). The actual controls on fruiting in this period and the factors determining the periods are not fully known. Certainly, precipitation is an important factor; during a dry season, few Helvellas are found and during a wet one they are relatively abundant. Furthermore, it has been my experience that if a species fails to fruit during its "usual" time, it is not likely to fruit at any other time that season. It thus appears that the timing of fruiting is determined by several factors, of which moisture, while important, is only one. Within a growing season, there is a roughly predictable order and length of fruiting for each species in a given area (Table 1). However, the short fruiting time attributed to several species may not reflect the actual potential of those species. The reportedly short fruiting time is due in part to the relative scarcity of some species, and, for autumnal species at least, in part to the lack of collections from the fall months.

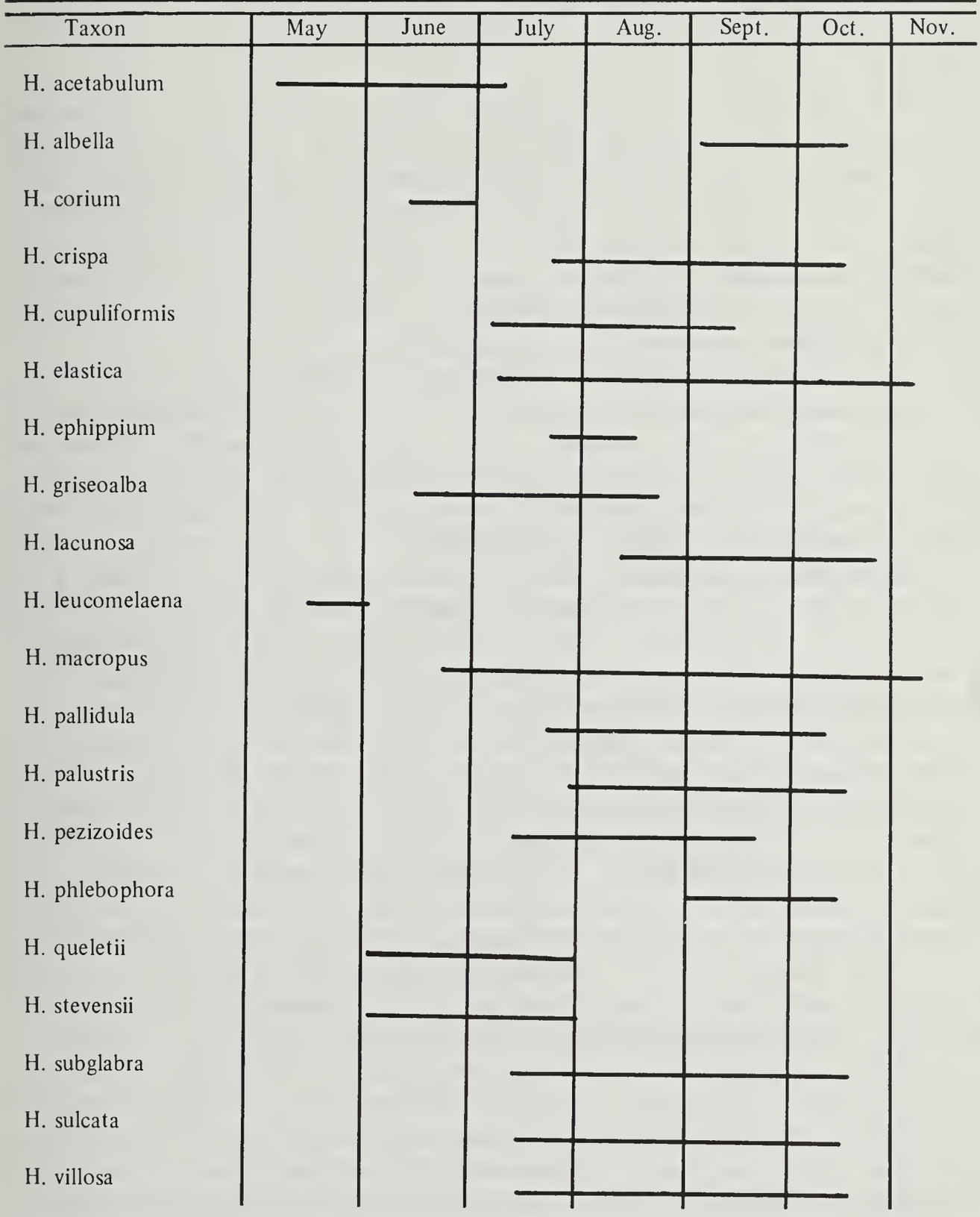
Habitat variation is difficult to catalogue precisely. There is currently no evidence that any species of *Helvella* is mycorrhizal, parasitic, or carbonicolous. Most are terrestrial, although several (*H. pezizoides, H. macropus,* and *H. sulcata*) are frequently lignicolous. In terms of water requirements, the terrestrial species can be divided into three broad groups: (1) those most often found in relatively dry, well drained habitats; (2) those which fruit in either dry or wet habitats; and (3) those known exclusively from wet habitats. The first group characteristically fruits along roads and paths in sandy soil and is exemplified by *H. stevensii, H. leucomelaena,* and *H. ephippium.* The second group includes such species as *H. crispa* and *H. elastica* which have been found in swamps, bogs, and well drained sandy soil. The species in the last group are known only from very damp to nearly saturated habitats along streams and in bogs and swamps. Examples of this group include *H. albella* and *H. palustris.*

A given habitat can be occupied by a number of species, and more than one may fruit at a given time. In Reese's Bog, between Douglas Lake and Burt Lake in Cheboygan County, eight species of *Helvella* have been collected. During September of 1969 and October of 1971, *H. palustris, H. albella, H. crispa,* and *H. elastica* were found along the streams near the eastern end of the area and *H. macropus* was found on drier ground in the area. Frequently, two or more species fruited in close proximity, often with their ascocarps intermixed. Typically, where species mixtures were observed, the species represented different sections of the genus or were distantly related within a section as with *H. albella* and *H. elastica.* Such observations indicate that the mycelium of several species can exist in close proximity and possibly be intermixed without apparent hybridization occurring.

CONSIDERATION OF CHARACTERS

Both features observable with the naked eye (morphological) and those best examined with the aid of a microscope (anatomical) were used in delimiting sections and species.

TABLE 1. Fruiting periods of Michigan species of *Helvella*.



Apothecial shape in *Helvella* is much more variable than in most genera of operculate Discomycetes. *Helvella* apothecia may be cupulate, plane, saddle-shaped with a shallow or deep sinus, subglobose, or subhemispherical depending on the species. In individual species, apothecial shape varies within rather definite limits; however, several species have similar ranges of variation. For example, *H. stevensii, H. pezizoides,* and *H. albella* are similar in size and

shape so that characters such as color and time of fruiting must be used to distinguish them. Some species, e.g. *H. crispa,* are quite constant in apothecial shape whereas in others, especially *H. lacunosa,* the apothecium is much more variable.

The curvature of the apothecial margin is important in delimiting sections and to some extent species within the genus. The margin may curve so as to protect the hymenial surface during emergence of the ascocarp (Figs. 43, 45, 48) or it may be straight to flaring and not shield the hymenial surface (Figs. 33, 35, 40). In Sections *Helvella* and *Elasticae* (excluding *H. elastica*), the margin is rolled or curved over the hymenial surface as the ascocarps emerge and gradually unrolls as they expand; in contrast, species in Section *Lacunosae* consistently lack such curvature.

The presence of absence of projecting hyphae on the sterile surface of the apothecium is relatively constant at the species level. As with margin curvature, there are two extremes, those taxa with projecting hyphae and those without them. However, in Section *Elasticae, H. albella* is pubescent when young but becomes progressively less pubescent with age until in some older specimens, the pubescence is not visible.

Stipe shape, particularly the outline in cross section, exhibits great variation in the genus, but is relatively constant for each species. Taxa with a terete stipe as well as those with a costate one are included with sessile to subsessile taxa in the genus. A few species have a stipe morphology which varies within individual collections as in *Helvella queletii* and *H. corium.*

The first anatomical character to be considered is the arrangement of tissues within the ascocarp. In all species it is basically the same, and this uniformity of structure unites the genus. The apothecia have three distinct regions: (1) the hymenium of asci and paraphyses, (2) the medullary excipulum of *textura intricata,* and (3) the ectal excipulum. In species with a pubescent sterile surface on the apothecium, the ectal excipulum is composed of *textura angularis*; in glabrous species it is modified *textura angularis* where the hyphal end-cells form a palisade at the surface subtended by a few polyhedric to isodiametric cells. Species with the palisade type of excipulum may have a few projecting hyphae, but are never truly pubescent to villose.

Helvella pigments are either predominantly tan to brown or gray to black. Under the microscope, these color differences are less pronounced, but two patterns of pigment distribution have been noted: intracellular pigments and pigments associated with hyphal walls. Intracellular pigment occurs in the buff to tan or brown series of species and wall pigments are characteristic of the gray to black species. The intracellular pigment occurs in groups of cells in the inner part of the ectal excipulum near the margin of the apothecium and in the ultimate cells of the paraphyses. Both acidic (lactic acid) and basic (KOH) mounting media can be used to study it, although the pigment seems to be slowly soluble in KOH.

The situation where pigment is associated with the hyphal walls is similar to the hyphal encrustations found in many species of Basidiomycetes. The pigment may be deposited on the ends as well as the sides of a hyphal

cell and may be continuous or discontinuous. None of the mounting media used dissolved or visibly altered the pigment. Pigment deposition in an even and continuous pattern is characteristic of the paraphyses of most gray to black species and the ectal excipulum of *Helvella corium.* It has also been observed on hyphal walls of the projecting hyphae on the sterile surface of the apothecium in *H. macropus* and *H. griseoalba.* Where the pigment is discontinuous, it may have been originally deposited as an even layer as part of the hyphal wall. If the pigmented layer was relatively inelastic, subsequent cell enlargement would cause its rupture and leave irregular patches of pigmented material on the cells. Remnants of the pigmented layer are usually visible as rings or sheaths around the septa and as irregular patches of material scattered along the hyphae. In some species (*H. crispa* especially), where no pigment is normally evident, unevenly thickened walls may be seen on some hyphae, indicating that the type of hyphal deposit discussed above need not necessarily be pigmented.

The type of ascus development, whether aporhynchous or pleurorhynchous (Chadefaud, 1943; Berthet, 1964) is a character of importance in defining sections. Only *Helvella leucomelaena* exhibits aporhynchous development and Section *Leucomelaenae* is herein limited to species with this character. All other Michigan species of *Helvella* show the typical pleurorhynchous pattern.

Ascospore characters in *Helvella* are some of the most and least useful characters in the taxonomy of the group. *Helvella* ascospores vary in shape from short-ellipsoid to suboblong to subfusiform. Mature spores contain at least one large oil droplet which nearly fills the spore with none to several smaller droplets at each end. Aside from *H. macropus* which has subfusiform spores, those of Michigan Helvellas are very similar in shape and the character is of relatively little use in separating closely related taxa. Spore size usually varies within a 3-5 μ range in length and 2-3 μ range in width, but within a given section of the genus, the ranges often overlap in such a way that the character is seldom useful in separating species.

Spore ornamentation is a reliable character only under some conditions. In *Helvella,* two types of spore ornamentation have been observed. The first, observed in all sections except Sections *Leucomelaenae* and *Acetabulum,* consists of warts 1-2 μ high and 1-3(-5) μ in diameter which may have radiating ridges extending out from the base (Figs. 8, 10). The spores appear verrucose-rugulose. When discharged spores are collected from fresh specimens, spores with this type of ornamentation are seldom found and never constitute a high proportion of the total spore cast. The character is variable within a species and even within a given apothecium in occurrence. In apothecial sections, asci containing verrucose-rugulose spores often are collapsed and do not become turgid when an attempt is made to rehydrate them.

The formation and development of this type of ornamentation was studied by LeGal (1947); she concluded it was not a "true" type of ornamentation; rather it was composed of accidental swellings in one wall layer which formed the warts. She also considered it to be non-permanent. My

observations also indicate this type of ornamentation originates in the spore, but that it is permanent. The impetus for its formation remains unknown.

The second type of spore ornamentation has been observed only in Section *Macropodes,* particularly in *Helvella macropus.* The verruculose ornamentation consists of small warts up to 0.2-0.3 μ in diameter scattered over the surface of the spore (Figs. 10, 11). The small warts are present on spores still in the asci and are invariably present on the discharged, presumably mature spores of *H. macropus.* However, care must be taken when studying this type of ornamentation not to destroy it. For example, two adjoining pieces of an apothecium of *H. macropus* were prepared for examination by two techniques. One piece was soaked in 25-30% NH_4OH for two hours at room temperature, washed in two changes of distilled water, blotted, and sectioned. The sections were mounted in one of the following reagents for study: Poirrier's blue in lactic acid, KOH, or Melzer's reagent. The second piece was soaked in distilled water for 30-40 minutes, blotted, and sectioned. Different sections were mounted in each of the reagents listed above. Spores from material soaked in NH_4OH and mounted in KOH were verrucose-rugulose or smooth as were those mounted in Melzer's reagent or lactic acid. Spores from material soaked in distilled water and mounted in KOH were smooth or verrucose-rugulose, whereas spores from the same piece mounted in either Melzer's reagent or lactic acid were either verruculose or verruculose and verrucose-rugulose. Thus, basic reagents apparently selectively destroy the verruculose type of spore ornamentation but not the coarser ornamentation. The use of strong basic chemicals in preparing *Helvella* spores for examination should be avoided.

Little attention has been given to the verruculose ornamentation in the literature. LeGal (1947) did not mention it; however, in a later publication (1963) she stated that *Helvella macropus* has "une ornementation véritable, composée des très fines pustules denses et plus ou moins anastomosées, visible nettement àpres coloration au bleu lactic" in addition to the verrucose-rugulose ornamentation. Boudier (1907) and Rifai (1968) also reported verruculose ornamentation on the spores of *H. macropus.* In contrast, Dissing (1966) and Dissing and Nannfeldt (1966) dismiss such ornamentation as follows: "spores . . . often with conspicuous pustules and/or delicately warted when young." Dissing and Nannfeldt also stated in their discussion of *H. macropus:* "Spores with delicate warts . . . have not been seen in any other *Helvella* species. When mature the spores are in all collections smooth." It is probable that the method used by Dissing to revive his material destroyed this ornamentation; he soaked the dried material for 1-2 hours in 25% NH_4OH before sectioning and examining it (Dissing, 1966).

The distribution and permanence of the two types of ornamentation within the genus are worthy of consideration. The verruculose type is consistently present in *Helvella macropus* and it has occasionally been observed in *H. villosa.* In the latter species, the warts were even smaller than in *H. macropus* and were difficult to resolve in many cases. The small warts do not seem to represent a stage in spore maturation or a response to a set of

environmental conditions, as may be the case with the larger warts. There is some preliminary evidence that the small warts may be present on the large warts when both types are present.

In summary, most morphological and anatomical characters exhibit nearly continuous variation in the genus as a whole. Each species, however, represents only one area on the spectrum of variation for each character, and several species may share a given part of the spectrum for a character. Thus a group of characters must be used to delimit species.

GLOSSARY

Aporhynchous: Ascus development in which no crozier is formed; instead two binucleate cells are delimited at the tip of an ascogenous hypha and the ultimate cell enlarges to form the mature ascus. Fig. 15.

Apothecium: The exposed hymenium and its immediate supporting tissues in some ascocarps. Figs. 1, 2, 3, A.

Compressed: (1) elliptic or flattened-elliptic in cross section, as a stipe, or (2) pressed close together as if pushed together, as the lobes of some apothecia.

Costate: Ribbed or fluted.

Crozier: The hook-like curve of an ascogenous hypha with pleurorhynchous development.

Even: Lacking ribs, furrows, or striations (not to be confused with glabrous which refers to the absence of hairs.)

Ectal excipulum: The outermost differentiated tissue in a Discomycete. Fig. 3, E.

Hymenial surface: The surface of an ascocarp bearing the hymenium. Figs. 1, 2, HS.

Lacunose: Having cavities, holes, or gaps.

Medullary excipulum: The tissue between the hymenium and ectal excipulum in a Discomycete. Fig. 3, M.

Mitrate: Miter-like in shape, resembling a cap with two raised lobes worn by some bishops, especially the forms common in the seventeenth and eighteenth centuries.

Pleurorhynchous: Ascus development in which an ascogenous hypha is partitioned into uninucleate ultimate cell, binucleate penultimate cell, and uninucleate antepenultimate cell and the hypha bends so the uninucleate cells are brought near or in contact with each other and may fuse (in *Helvella* they fuse). Figs. 16, 17.

Sterile surface: The surface of an apothecium opposite the hymenium, not bearing asci and paraphyses. Figs. 1, 2, SS.

Stipe: A structure which elevates the apothecium. Figs. 1, 2, S.

Sulcate: Furrowed or grooved.

Terete: Cylindrical or elongate and circular in cross section.

Textura angularis: A tissue of short polyhedral cells without intercellular spaces (see Korf, 1958). Fig. 4.

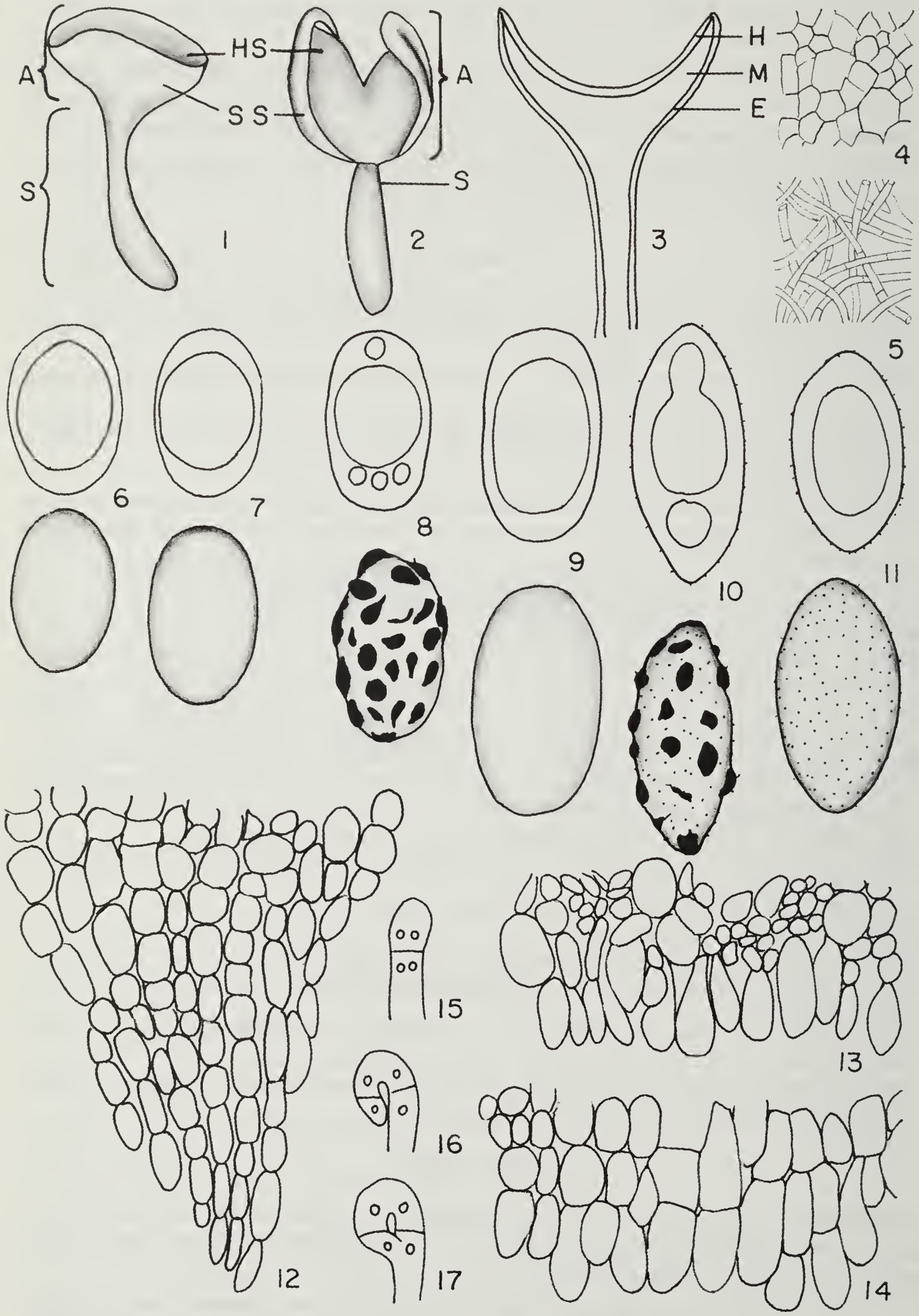
Textura globosa: A tissue of globose to subglobose cells with intercellular spaces (see Korf, 1958).

Textura intricata: A tissue of interwoven irregularly disposed narrow hyphae with distinct interhyphal spaces (see Korf, 1958). Fig. 5.

SYSTEMATICS

Explanatory note: Only nomenclatural synonyms are listed for the species names unless otherwise noted. Taxonomic sysnonyms are listed only at the generic level unless otherwise noted.

All the collections examined are deposited in the University of Michigan Herbarium unless the citation is followed by an appropriate symbol from the *Index Herbariorum* (Lanjouw & Stafleu, 1964) indicating another herbarium.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My collections made prior to April 1970 are listed under "N. J. Smith." After that time, they are listed under "N. S. Weber."

In the descriptions, when discussing the presence or absence of vesture on an ascocarp, it is assumed that at least a 10X hand lens is used. Color names enclosed in quotation marks are those of Ridgway (1912); color terms followed by (M) are from Kornerup and Wanschner (1967).

Helvella Fries, Systema Mycologicum 2: 13. 1822. emend. Nannfeldt, Svensk Bot. Tidskr. 31: 54. 1937.

Type species: *Helvella crispa* Fries, Syst. Mycol. 2: 14. 1822.

Peziza tribus *Helvelloideae* sect. *Acetabula* Fr., Syst. Mycol. 2: 43. 1822.
Acetabula (Fr.) Fckl., Symbol. Mycol. 330. 1869.
Macropodia Fckl., Symbol. Mycol. 331. 1869.
Cyathipodia Boud., Hist. Class. Disc. d'Eur. 39. 1907.
Leptopodia Boud., Bull. Soc. Mycol. France 1: 99. 1885.
Fuckelina O. Kuntze, Rev. Gen. Pl. 2: 852. 1891.
Paxina O. Kuntze, Rev. Gen. Pl. 2: 864. 1891.
Phleboscyphus Clem., Bull Torrey Bot. Club 30: 93. 1903.
Cowlesia Nieuwl., Am. Midl. Nat. 4: 379. 1916.
Costapeda Falck, Mycol. Unters. Ber. 1: 377. 1923.
Tubipeda Falck, Mycol. Unters. Ber. 1: 377. 1923.
Globopilea Beauseig., Contr. Etude Fl. Mycol. Landes 204. 1926.

Apothecium variable in shape, but typically cupulate, saddle-shaped, or mitrate; 1-10 cm broad. Hymenial surface rarely white, more often cream

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Fig. 1. Ascocarp: A, cupulate apothecium; S, stipe; HS, hymenial surface; SS, sterile surface of apothecium.

Fig. 2. Ascocarp: A, saddle-shaped apothecium; S, stipe; HS, hymenial surface; SS, sterile surface of apothecium.

Fig. 3. Longitudinal section of an ascocarp: H, hymenium; M, medullary excipulum; E, ectal excipulum.

Fig. 4. *Textura angularis.*

Fig. 5. *Textura intricata.*

Fig. 6. Spores of *H. griseoalba,* ×1930, N. J. Smith 982.

Fig. 7. Spores of *H. pallidula,* ×1930, N. J. Smith 397.

Fig. 8. Spores of *H. subglabra,* ×1930, N. J. Smith 2145.

Fig. 9. Spores of *H. leucomelaena,* ×1930, N. J. Smith 991.

Fig. 10. Spores of *H. macropus* var. *macropus,* ×1930, N. J. Smith 1273.

Fig. 11. Spores of *H. macropus* var. *brevis,* ×1930, N. J. Smith 1113.

Fig. 12. Fascicle of hyphae from ectal excipulum of *H. macropus.*

Fig. 13. Ectal excipulum of *H. sulcata.*

Fig. 14. Ectal excipulum of *H. elastica.*

Fig. 15. Aporhynchous type of ascus development (after Chadefaud, 1943).

Fig. 16, 17. Pleurorhynchous ascus development with (17) or without (16) fusion of ultimate and antepenultimate cells (after Chadefaud, 1943).

color to buff, tan, umber brown, gray-brown, gray, brownish gray, or black; even or rugose.

Stipe absent or present and one of three types: (1) terete to compressed, even, slender; (2) variable in cross section with distinct sharp-edged ribs, slender to stout; or (3) rounded in cross section with low rounded ribs, slender to stout; rarely white, typically cream color, buff, drab, gray, or black.

Spores ellipsoid, oblong, broadly ellipsoid to fusiform; with a central oil droplet and none to several smaller droplets at each end; hyaline; smooth to verruculose, occasionally also verrucose-rugulose; tetranucleate at maturity. Asci operculate, pleurorhynchous or aporhynchous, non-amyloid, 8-spored. Paraphyses straight, clavate, 2.3-3.5 μ broad at the base with the clava up to 10 μ broad.

Excipulum of the apothecium of *textura angularis* or a palisade of hyphal end-cells. Medullary excipulum of *textura intricata.* Ectal excipulum of the stipe similar in color and structure to that of the apothecium, in costate stipes typically thinnest over the ribs and thickest in the hollows. Medullary excipulum of *textura intricata.*

KEY TO SECTIONS OF *HELVELLA*

1. Apothecium cupulate to plane at maturity 2
1. Apothecium saddle-shaped, convex or irregularly lobed and folded at maturity. . . 5
   2. Apothecium stipitate, the stipe terete or nearly so, occasionally with a few low rounded ribs . . . . . Sect. *Macropodes*
   2. Apothecium subsessile to stipitate, the stipe or base of the ascocarp ribbed or folded 3
3. Base of ascocarp with definite ribs 4
3. Base of ascocarp appearing folded or gathered, the ribs not distinct from the rest of the apothecium . . . . . (1. *H. leucomelaena*) Sect. *Leucomelaenae*
   4. Ribs continuing on the sterile surface of the apothecium . . . . . Sect. *Acetabulum*
   4. Ribs not continuing on the sterile surface of the apothecium . . . Sect. *Macropodes*
5. Stipe even and terete or compressed, occasionally with a few basal clefts 6
5. Stipe ribbed throughout its length, variable in cross section 7
   6. Hymenial surface gray to black or occasionally drab; stipe gray to black, rarely drab . . . . . Sect. *Ephippium*
   6. Hymenial surface tan to gray-brown; stipe buff to nearly white . . . Sect. *Elasticae*
7. Hymenial surface gray to black; sterile surface of the apothecium glabrous . . . . . Sect. *Lacunosae*
7. Hymenial surface buff to umber-brown; sterile surface of the apothecium pubescent to villose when young . . . . . (21. *H. crispa*) Sect. *Helvella*

SECTION *ACETABULUM*, KEY TO SPECIES

1. Hymenial surface brown or grayish brown; pigment in the extal excipulum intracellular. . . . . 2. *H. acetabulum*
1. Hymenial surface gray; pigment in the ectal excipulum in the hyphal walls when present. . . . . 3. *H. griseoalba*

SECTION *MACROPODES*, KEY TO SPECIES

1. Spores fusiform to subfusiform 2
1. Spores oblong to ellipsoid 3
   2. Stipe 10-30(-70) mm long; spores (19-)21-24(-27) μ long . . . . . 4. *H. macropus* var. *macropus*
   2. Stipe 8-16 mm long; spores 18.5-23 μ long . . . . . 4a. *H. macropus* var. *brevis*

3. Hymenial surface black 4
3. Hymenial surface drab, gray-brown, or gray 5
   4. Pigment on hyphal walls in ectal excipulum of apothecium a continuous layer . . . . . 5. *H. corium*
   4. Pigment on hyphal walls in ectal excipulum of apothecium discontinuous, in patches or rings . . . . . 8. *H. villosa*
5. Stipe with distinct round to sharp-edged ribs . . . . . 6. *H. queletii*
5. Stipe terete and even 6
   6. Pigment present in the ectal excipulum of the apothecium and concentrated either in the ctyoplasm or on the hyphal walls 7
   6. Pigment absent from the ectal excipulum of the apothecium as viewed in section, cells and hyphal walls not colored . . . . . 7. *H. pallidula*
7. Pigment in the apothecium deposited on the hyphal walls in the medullary and/or ectal excipulum . . . . . 8. *H. villosa*
7. Pigment in the apothecium localized within the cells of the ectal excipulum; medullary hyphae hyaline . . . . . 9. *H. cupuliformis*

SECTION *EPHIPPIUM,* KEY TO SPECIES

1. Sterile surface of apothecium pubescent to villose 2
1. Sterile surface of apothecium glabrous to minutely pruinose 3
   2. Hyphae of the apothecium seldom or never with brown walls . . . 10. *H. ephippium*
   2. Hyphae of the apothecium frequently with brown walls, especially at the junction of the medullary and ectal excipula . . . . . 11. *H. pezizoides*
3. Hymenium black at maturity; stipe and sterile surface of apothecium black or dark gray; most hyphal cells in the ectal excipulum of the apothecium with brown walls . . . . . 12. *H. atra*
3. Hymenium dark gray to brownish gray or drab at maturity; stipe and sterile surface of the apothecium drab to gray, never black; scattered hyphal cells in the ectal excipulum of the apothecium with brown walls . . . . . 13. *H. subglabra*

SECTION *LACUNOSAE,* KEY TO SPECIES

1. Apothecium convex to hemispheric at maturity . . . . . 14. *H. phlebophora*
1. Apothecium saddle-shaped, lobed or mitrate at maturity 2
   2. Apothecium saddle-shaped to lobed with a distinct sinus; hymenial surface and sterile surface of the apothecium even . . . . . 15. *H. sulcata*
   2. Not with the above combination of characters 3
3. Apothecium mitrate to irregularly saddle-shaped or lobed; stipe lacunose . . . . . 16. *H. lacunosa*
3. Apothecium peltate to shallowly saddle-shaped; stipe not lacunose . . . 17. *H. palustris*

SECTION *ELASTICAE,* KEY TO SPECIES

1. Sterile surface of the apothecium glabrous throughout development; margin of apothecium not curving toward the hymenium and not obscuring it when young . . . . . 18. *H. elastica*
1. Sterile surface of the apothecium pubescent when young, pubescent or glabrous when mature; margin of apothecium curving toward hymenium when young and often obscuring it. 2
   2. Hymenial surface pale buff to tan . . . . . 19. *H. stevensii*
   2. Hymenial surface light to dark gray-brown . . . . . 20. *H. albella*

Section *Leucomelaenae* Dissing, Dansk Bot. Ark. 25: 36. 1966.
Type species: *Helvella leucomelaena.*

Apothecium subsessile to short stipitate, regularly cupulate to plane. Margin flaring, not curving over the hymenial surface; edge entire to crenate or lacerate. Hymenial surface dark gray to fuscous. Sterile surface of the

apothecium granulose, even near the margin but with low rounded ribs basally. Stipe present or absent and then base of ascocarp with low broadly rounded ribs or rarely terete, finely granulose. Asci aporhynchous.

One species, *H. leucomelaena,* known from Michigan.

1. *Helvella leucomelaena* (Pers.) Nannf. in Lundell & Nannfeldt, Fungi Exsic. Suec. Praes. Upsal. Fasc. 19-20: 21, No. 952. 1941 (as *Helvella leucomelas*).

Peziza leucomelas Pers., Mycol. Eur. 1: 219. 1822.

Aleuria leucomelas (Pers.) Gill., Champ. Fr. Disc. 37. 1879.

Acetabula leucomelas (Pers.) Boud., Bull. Soc. Mycol. France 1: 100. 1885.

Paxina leucomelas (Pers.) O. Kuntze, Rev. Gen. Pl. 2: 264. 1891.

Type: None selected (Dissing, 1966).

Illustrations: Figs. 9, 18.

Apothecium 1-6 cm broad, 1-4 cm high, cupulate. Margin straight to flaring; edge entire to crenate or lacerate in age. Hymenial surface gray to dark brownish gray ("Fuscous"), even. Sterile surface of the apothecium nearly concolorous with the hymenial surface at the margin to cream color or off-white basally; finely granulose-roughened; base appearing folded or gathered, the ribs broad and not distinct from other parts of the ascocarp in shape, color or texture, not reaching the margin.

Stipe poorly developed or absent, stipe area expanding smoothly into the apothecium with broad low ribs which taper out on the apothecium; off-white to dingy gray; glabrous to finely granulose.

Spores 20-23(-25) × 10.5-14 μ, rounded oblong, with a single oil droplet, smooth. Hymenium 280-340 μ thick. Paraphyses hyaline to diffusely light tan; clavate, the clava 5-8 μ broad. Asci 8-spored, 14-16 μ broad.

Ectal excipulum of the apothecium 90-250 μ thick; poorly delimited from the medullary excipulum; of *textura angularis* with individual hyphae and groups of hyphae projecting irregularly along the outer edge; hyaline to diffusely brown in the inner part, end cells diffusely tan to brown due to wall pigmentation. Medullary excipulum 100-500(-700) μ thick; of *textura intricata,* the hyphae hyaline, 3-5(-10) μ wide.

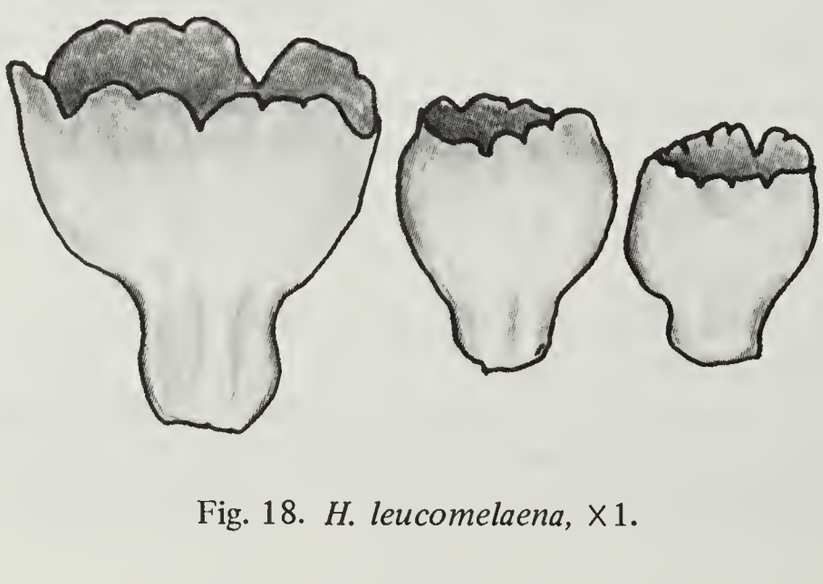

Fig. 18. *H. leucomelaena,* ×1.

Scattered to gregarious on compacted, well drained soil along paths, roads, and parking lots, frequently under pine. It fruits in the spring (late May around Ann Arbor) and is one of the first Helvellas to appear.

Helvella leucomelaena can be distinguished by the combination of fuscous, cupulate, subsessile apothecia and broadly rounded ribs at the base of the ascocarp. Furthermore, it is the only species of *Helvella* in Michigan with aporhynchous asci. The spores are consistently smooth and contain a single oil droplet which is more stable than those of any other Michigan species of *Helvella*. *Helvella leucomelaena* has been found relatively few times in the state, but it may be more common farther south. I have seen good fruitings of it in Ohio and Kentucky, but not in Michigan.

Material examined: MICHIGAN: WASHTENAW Co.: F. Hoseney 67; M. Lange, 23 May 1947; H. Peters 1258; S. J. Mazzer 4021; OHIO: HOCKING Co.: N. J. Smith 991.

Section *Acetabulum* Dissing, Dansk Bot. Ark. 25: 49. 1966.
Type species: *Helvella acetabulum*.

Apothecium subsessile to stipitate; regularly to irregularly cupulate when young, cupulate to nearly plane in age. Margin flaring to variously curved but not obscuring the hymenium. Hymenial surface light to dark gray, brown, or brownish gray. Sterile surface of the apothecium concolorous with the hymenial surface or paler and then nearly white to cream color; glabrous to finely pubescent near the margin; ribbed. Base or stipe expanding into the apothecium, costate, white to cream color, glabrous to finely roughened. Asci pleurorhynchous.

Two species known from Michigan.

2. *Helvella acetabulum* (Fries) Quélet, Enchiridion Fungorum 275. 1886.
Peziza acetabulum Fries, Syst. Mycol. 2: 44. 1822. (Based on *Peziza acetabulum* Linnaeus, Species Plantarum 2: 1181. 1753.)
Aleuria acetabulum (Fr.) Gill., Champ. Fr. Disc. 32, 1879.
Paxina acetabulum (Fr.) O. Kuntze, Rev. Gen. Pl. 2: 864. 1891.
Acetabula acetabulum (Fr.) Underwood & Earle, Bull. St. Agr. Exp. Sta. (Alabama) 80: 200. 1897.
Phleboscyphus acetabulum (Fr.) Clem., Crypt. Form. Colorado 298. 1907.
Type: Pl. 13, Fig. 1 in Vaillant, Botanicon Parisienne. 1727. (Dissing, 1966).
Illustrations: Figs. 19-21.

Apothecium 2-8 cm broad, up to 4 cm deep; cupulate when young, cupulate to nearly plane in age. Margin when young sometimes inclined over the hymenium to straight, straight to flaring in age; edge entire or in age irregularly lacerate. Hymenial surface light to dark brown, "Snuff Brown," "Buckthorn Brown," "Dresden Brown" to "Bister"; even or undulate. Sterile surface of the apothecium concolorous with the hymenial surface near the margin to pale cream color at the base; finely pubescent to furfuraceous at the margin to nearly glabrous at the base; ribbed, the ribs typically forking and not interconnected, rounded to sharp-edged, concolorous with the sterile surface.

Fig. 19. *H. acetabulum,* ×1, N. J. Smith, Spring 1968.

Fig. 20. *H. acetabulum,* ×½, N. J. Smith 908.

Stipe absent to present; up to 9 cm long, 3 cm broad; broadening into the apothecium; costate, the ribs rounded to sharp-edged, branching and sometimes anastomosing, extending onto the sterile surface of the apothecium; cream color when well developed to brownish when the apothecium is subsessile.

Spores 16-18(-19.5) × 11-13.5 μ; broadly ellipsoid; when fresh or revived in water with one central oil droplet; smooth, only rarely verrucose-rugulose. Hymenium 200-300 μ thick. Paraphyses pale brown due to cytoplasmic pigment; clavate, the clava 4-10 μ broad. Asci 8-spored, 12-14 μ broad.

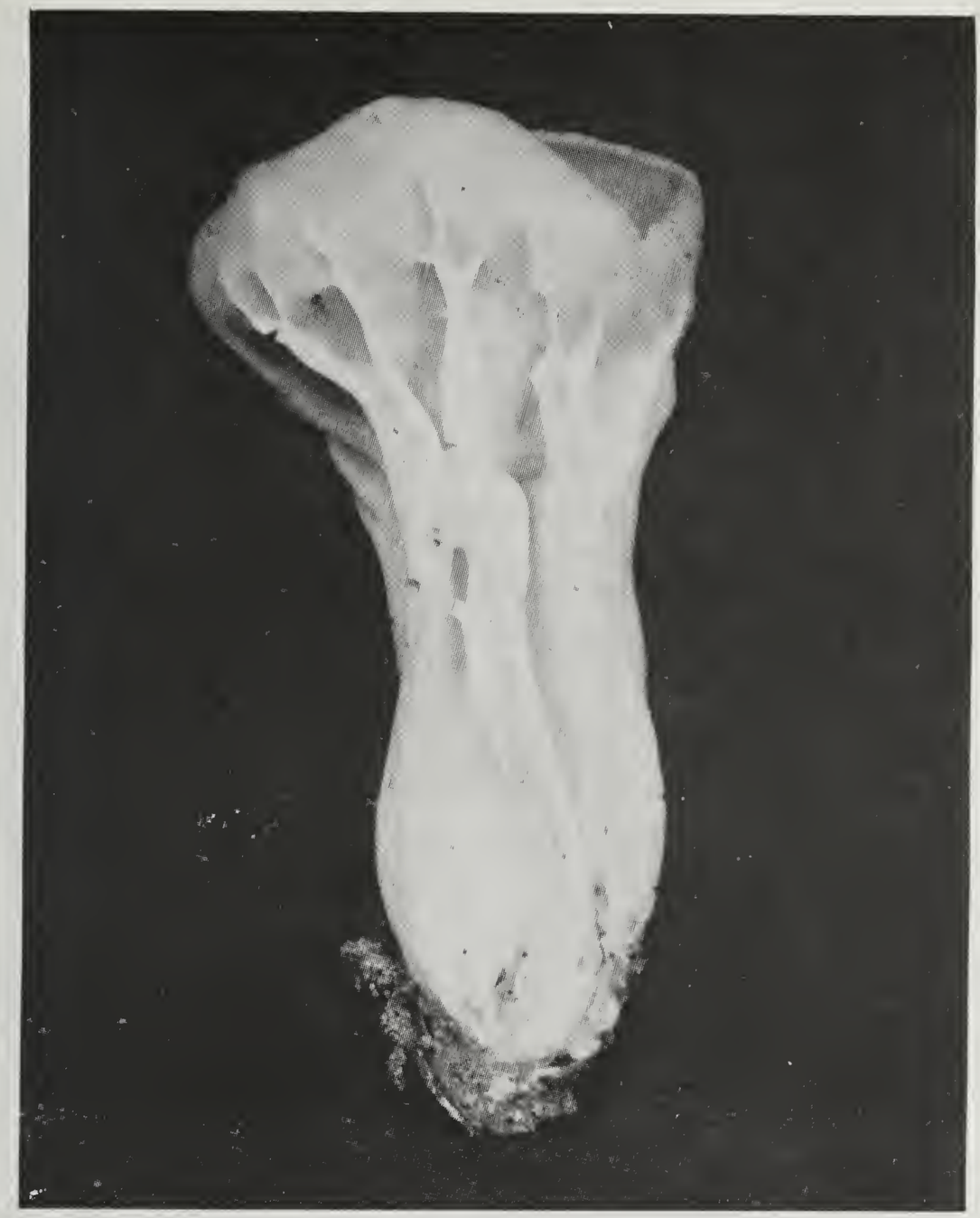

Fig. 21. *H. acetabulum,* ×1, N. J. Smith 977.

Ectal excipulum of the apothecium 90-175 μ thick; of *textura angularis* with individual hyphae and fascicles of hyphae projecting irregularly along the outer edge, especially near the margin; inner part hyaline, outer part and end-cells diffusely brown due to intracellular cytoplasmic pigment. Medullary excipulum 100-600 μ thick; of *textura intricata,* the hyphae hyaline, 3-7 μ wide.

Scattered to gregarious, typically under hardwoods on well drained soil. It is frequently found along roads and paths and fruits in the spring and early summer.

The brown colors and cytoplasmic pigment in *Helvella acetabulum* distinguish it from *H. griseoalba* which is gray and has wall pigments.

Helvella acetabulum was described by Fries (1822) as "fuliginea" and "fusco-expallens, subfuliginea" which implies a smoky gray color (Wharton,

1884); Dissing (1966) interprets the species as being "brownish to dark brown." The Michigan material, when fresh, has definite brown tones which usually become more pronounced on drying. In Section *Macropodes*, brownish tones correlate with brownish cytoplasmic pigments and gray tones with wall pigment. A similar situation occurs in Section *Acetabulum*. In the Michigan material of *Helvella acetabulum*, brown intracellular pigment was observed. It seems probable that a species with pure gray colors and extracellular pigment might also occur in this section. The species most likely to fit these specifications was described as *Peziza costata* by Fries (1851) and transferred to *Helvella* as *H. costifera* Nannfeldt (1953) (not *H. costata* Fries). It was described as "dilute griseo albescens" by Fries which means a clear gray. The type of *H. costifera* was examined and instead of wall pigmentation, abundant intracellular brown pigment was observed in the ectal excipulum of the apothecium. In addition, the sterile surface of the apothecium was a dull brown similar to that of Michigan material of *H. acetabulum* and not "whitish to cream" when dried as mentioned by Dissing (1966). The pattern of pigmentation attributed to *H. costifera* thus appears to be unique in the genus, and one can either reject the information on pigment localization or assume that *H. costifera* has not yet been found in this area. The color distinctions given by Fries for these species are considered important, and the Michigan material is consequently assigned to *H. acetabulum*. Although Dissing (1966) reported *H. costifera* from Michigan, it is not included in this work (see also discussion of *H. griseoalba*).

Material examined: MICHIGAN: ALGER Co.: A. H. Smith 75466; BARRY Co.: N. J. Smith 908; CHEBOYGAN Co.: A. H. Smith 32180, 75351; N. J. Smith 983, 985, 1009, 2174, 2176, 2181, 2210; INGHAM Co.: A. H. Smith 19 June 1934; LIVINGSTON Co.: N. J. Smith 957; OTSEGO Co.: A. H. Smith 75453; ROSCOMMON Co.: B. B. Kanouse 527; WASHTENAW Co.: A. H. Smith 20423, 20429; N. J. Smith Spring 1968, 929, 960, 961, 962, 970, 971, 973, 974, 975, 976, 977, 978, 979, 980.

3. *Helvella* **griseoalba** sp. nov.

Type: Michigan: Cheboygan Co.: Grapevine Point, Douglas Lake, Univ. of Mich Biol. Sta., 10 June 1968, N. J. Smith 982 (MICH).

Illustrations: Figs. 6, 22.

Apothecium 1.5-4 cm latum, usque 1.2 cm profundum, cupulatum vel planum. Hymenium dilute griseum vel cinereum, aequatum. Pagina sterilis colorata similis hymenio, vel versa stipitem palescentem; impolita vel pubescens; costata, costae albae vel griseae, rotunda. Margo integer, curvus vel rectus. Stipes absens vel praesens, 1-2 cm longus, 7-13 mm crassus; albus; costatus, costae rotundae, interdum lacunosae; impolitus.

Sporae (15-) 16-18 × 10.5-12 μ, oblongae vel ellipsoidae. Hymenium 210-260 μ crassum. Paraphyses apice usque 5-10 μ clavato-incrassate, hyalinae. Asci 12-15 μ crassi. Excipulum 70-110 μ crassum, texturae angularis cum hyphis et fasciculis hyalinis vel fuscis. Medulla 100-500 μ crassa; texturae intricatae, hyphae hyalinae.

Specimen typicum in Herb. Univ. Mich. conservatum est; sub silvis frondiferis, Grapevine Point, Douglas Lake, Univ. Mich. Biol. Sta., Cheboygan Co., Michigan, 10 June 1968, leg. N. J. Smith 982.

Fig. 22. *H. griseoalba,* ×½, N. J. Smith 982.

Apothecium 1.5-4.5 cm broad, up to 1.2 cm deep; when young cupulate, in age nearly plane. Margin flaring or inclined toward the hymenial surface; edge entire to irregularly lacerate.

Stipe absent to distinct, 1-2 cm long, 7-13 mm wide; expanding into the apothecium; costate, the ribs rounded; occasionally lacunose in larger specimens; glabrous.

Spores (15-)16-18 × 10.5-12 μ; oblong to broadly ellipsoid; with one large droplet and occasionally up to 3 small droplets at each end when fresh, with one droplet when revived in water; smooth. Hymenium 210-260 μ thick. Paraphyses hyaline; narrowly clavate, the clava 3.5-5.5 μ broad. Asci 8-spored, 12-15 μ broad.

Ectal excipulum of the apothecium 70-110 μ thick, of *textura angularis* with scattered projecting hyphae and hyphal fascicles along the outer edge, hyaline to light brown in the projecting elements due to wall pigment. Medullary excipulum 100-500 μ thick; of *textura intricata,* the hyphae hyaline, 3.5-6.5 μ broad.

Scattered to gregarious on sandy soil under hardwoods, frequently along paths and roads. It has been found in June and July in Michigan.

Helvella griseoalba is characterized by a true gray hymenium and white to grayish white ribs which contrast with the brown and cream tones characteristic of *H. acetabulum.* Microscopically, the almost complete lack of pigment in the ectal excipulum with the exception of the brownish walls in the projecting hyphae serve to distinguish *H. griseoalba.* Pale material of *H. acetabulum* and *H. griseoalba* can be separated by the color of the stipe and ribs. *H. griseoalba* is close to the European species *H. costifera,* but the type of *H. costifera* has abundant intracellular pigment in the ectal excipulum (see discussion of *H. acetabulum*).

Material examined: MICHIGAN: BARRY Co.: A. H. Smith 78350; CHEBOYGAN Co.: A. H. Smith 25736, 25739, 39140, 75359, 75380; N. J. Smith 183, 982, 995, 1010, 1013; EMMET Co.: A. H. Smith 75471, 75472; N. J. Smith 93, 110, 2182, 2189, 2199, 2200, 2232; GRATIOT Co.: V. Potter 9709, 9712, 11150; SCHOOLCRAFT Co.: N. J. Smith 485; WASHTENAW Co.: N. S. Weber 22 June 1970.

A. H. Smith 72951 from Eberwhite woods in Ann Arbor may represent a variant of *Helvella griseoalba.* The spores were 17.5-19 × 12.5-13 μ, the hymenium 330-350 μ thick and the ectal excipulum of the apothecium 140-210 μ thick. The specimens were "pallid" to "grayish pallid" when fresh and lack intracellular and extracellular pigment.

Section *Macropodes* Dissing, Dansk Bot. Ark. 25: 62. 1966.
Type species: *Helvella macropus.*

Apothecium cupulate to plane, rarely slightly recurved in age. Margin curving over the hymenium or not when young, flaring in age; edge entire or occasionally lacerate. Hymenial surface light drab to dark brown, gray or black; even. Sterile surface of the apothecium granulose to villose, even. Stipe terete to compressed and even or with more or less prominent ribs; off-white, drab, dark grayish brown, gray or black; finely roughened, granulose to villose. Asci pleurorhynchnchous.

There are six species known from Michigan.

4. *Helvella macropus* (Fries) Karsten, Not. Sällsk. Fauna Fl. Fenn. Förh. 11: 224. 1870. var. *macropus*
Peziza macropus Fries, Syst. Mycol. 2: 57. 1822.
Macroscyphus macropus (Fr.) S. F. Gray, Nat. Arr. Brit. Pl. 1: 672. 1821.
Macropodia macropus (Fr.) Fckl., Symb. Mycol. 331. 1869.
Aleuria macropus (Fr.) Gill., Champ. Fr. Disc. 35. 1879.
Lachnea macropus (Fr.) Phill., Brit. Disc. 207. 1887.
Cowlesia macropus (Fr.) Nieuwl., Am. Midl., Nat. 4: 300. 1916.
Cyathipodia macropus (Fr.) Dennis, Brit. Cup-Fungi 7. 1960.
Type: None known (Dissing, 1966).
Illustrations: Figs. 10, 12, 23, 24.

Apothecium 1-3(-6) cm broad, up to 11 mm high; when young compressed-cupulate, at maturity compressed or regularly cupulate, rarely plane or recurved in age. Margin at first curving over the hymenial surface, in age plane to incurved; edge typically entire. Hymenial surface gray-brown, "Avellaneous" to "Drab" or "Buffy Brown"; even. Sterile surface of the apothecium concolorous with the hymenial surface or lighter, villose especially near the margin, even.

Stipe 1-3(-7) cm long, 1.5-5 mm thick; when young terete and even, tapering apically, in age often compressed with irregular basal clefts; concolorous with the sterile surface of the apothecium to off-white at the base; pubescent to villose.

Spores (19-) 21-24(-27) × 10.5-12.5 μ, subfusiform to fusiform; when fresh with one large central oil droplet and two smaller droplets, one at each end, which may have 0-5 still smaller droplets associated with them, variable when rehydrated; verruculose and often verrucose-rugulose in addition. Hymenium 210-330 μ thick. Paraphyses hyaline to pale tan; clavate, the clava 4-9 μ broad. Asci 8-spored, 14-17.5 μ wide.

Fig. 23. *H. macropus* var. *macropus,* about natural size, A. H. Smith 75674.

Fig. 24. *H. macropus* var. *macropus,* about natural size, A. H. Smith 75737.

Ectal excipulum of the apothecium 90-175 μ thick; of *textura angularis* with numerous fascicles of hyphae and individual hyphae projecting along the outer edge, particularly near the margin; hyaline or occasionally with light brown cell walls. Medullary excipulum 100-280(-400) μ thick; of *textura intricata,* the hyphae 3-10(-20) μ wide, hyaline but many near the margin and along the ectal excipulum with brown wall material. Ectal excipulum of the stipe 100-300 μ thick; of *textura angularis* with individual hyphae and hyphal fascicles projecting along the outer edge; hyaline or walls of hyphae in fascicles light brown. Medullary excipulum of *textura intricata,* the hyphae hyaline or occasionally with patches of brown wall material near the ectal excipulum, 2.5-5(-8) μ wide.

Solitary to scattered or occasionally gregarious on soil or rotting wood, commonly hardwood but occasionally on conifer wood. *Helvella macropus* has been found in wet as well as relatively dry areas. It fruits from summer through fall in Michigan.

The subfusiform verruculose spores and scattered areas of brown wall material on the hyphae of the medullary excipulum distinguish *Helvella macropus* from the other species in this section. It is the most frequently collected species of *Helvella* in Michigan.

Helvella macropus var. *macropus* typically has larger spores, a longer stipe, and a more compressed apothecium than *H. macropus* var. *brevis.* Most of the Michigan collections of the latter seemingly were made in relatively dry habitats, and it is possible that the distinctions between the two varieties merely represent differing responses to environmental conditions.

Material examined: CANADA: NOVA SCOTIA: K. Harrison 7993. U.S.A.: IDAHO: BONNER Co.: N. J. Smith 2120; MICHIGAN: ALGER Co.: C. H. Kauffman and A. H. Smith 23 Sept. 1929; E. B. and E. Mains 32-529; CHEBOYGAN Co.: M. V. Charlton G426; E. Chmieleswski 113; A. H. Smith 21529, 22281, 75598, 75674, 75930; N. J. Smith 582, 2244, 2245, 2250, 2267, 2286; CHIPPEWA Co.: H. Imshaug 3387, 3405; A. H. Smith 39612, 72163, 75621, 75993, 75994, 75997, 76004; N. J. Smith 2257, 2430; EMMET Co.: T. Brooks 1279, A. H. Smith 26257, 37109, 42512, 75633, 75622, 75737, 75801, 75802; N. J. Smith 2230; H. Thiers 902, 3524; GRATIOT Co.: V. Potter 4120, 5350, 5775, 7718, 7781, 8315, 9660, 9666, 10669; KEWEENAW Co.: A. H. Povah Fp. 376; LIVINGSTON Co.: F. Hoseney 851, 856, 867; A. H. Smith 62499; N. J. Smith 1965, 1966; R. Zehner 81; LUCE Co.: N. J. Smith 2369; MACKINAC Co.: N. J. Smith 2305; MARQUETTE Co.: P. Olexia 767; W. Patrick 1067, 1141; N. J. Smith 1160, 1194, 1202, 1228, 1231, 1232, 1233, 1234, 1236, 1241, 1265, 1273, 1325, 1335, 1338, 1363, 1525, 1532; MONTMORENCY Co.: N. J. Smith 621; OAKLAND Co.: J. F. Ammirati 2648; A. H. Smith 6341; ONTONAGON Co.: W. Patrick 1178; OTSEGO Co.: N. J. Smith 2228, 2246; PRESQUE ISLE Co.: N. J. Smith 274; ROSCOMMON Co.: N. J. Smith 2271, 2275; WASHTENAW Co.: F. Hoseney 410, 411; B. B. Kanouse 25 Sept. 1926; A. H. Smith 77171; R. Zehner 14.

4a. *Helvella macropus* var. *brevis* Peck, Bull. Torrey Bot. Club 29: 74. 1902. Type: Massachusetts: G. E. Morris (NYS).
Illustration: Fig. 11.

Apothecium 9-20 mm broad, up to 1 mm high; cupulate to nearly plane. Margin flaring, edge typically entire. Hymenial surface pale to dark brownish gray, "Drab," to "Hair Brown," or olive brown (M); even. Sterile surface of

the apothecium lighter than the hymenial surface or concolorous with it, pubescent to villose, even.

Stipe 5-15(-20) mm long, 1.5-5 mm thick; terete and even, tapering toward the apex; concolorous with the sterile surface of the apothecium to whitish at the base; finely granulose to pubescent.

Spores 18.5-23(-24) × 10.5-12 μ; broadly fusiform to pointed-ellipsoid; when fresh with one large central oil droplet and a smaller one at each end with 0-5 still smaller droplets with them, variable when rehydrated; verruculose, rarely verrucose-rugulose as well. Hymenium 200-300 μ thick. Paraphyses hyaline, clavate, 5.2-10.5 μ broad at the clava. Asci 8-spored, 14-19 μ broad.

Ectal excipulum of the apothecium 70-180 μ thick; of *textura angularis* with projecting hyphae and fascicles of hyphae along the outer edge, hyaline or outer part and fascicles of hyphae with light brown wall pigment. Medullary excipulum 100-300(-350) μ thick; of *textura intricata*, the hyphae hyaline except at the margin and along the excipulum where scattered hyphae have patches of brown wall material, 3.5-7 μ wide. Ectal excipulum of the stipe 70-140 μ thick; of *textura angularis* with projecting hyphae and hyphal fascicles along the outer edge; hyaline to diffusely tan, or in places with patches of brown wall material. Medullary excipulum of *textura intricata*, the hyphae 3-7 μ broad, some hyaline, some with areas of brown wall material.

Scattered to gregarious on sandy, well drained soil. It has been found under both hardwoods and conifers and is not known to be lignicolous. It fruits during the summer.

See discussion of *Helvella macropus* var. *macropus*.

Material examined: MASSACHUSETTS: G. E. Morris (NYS); MICHIGAN: CHEBOYGAN Co.: A. H. Smith 21528, 75476; N. J. Smith 1012; LIVINGSTON Co.: F. Hoseney 815; MARQUETTE Co.: N. J. Smith 1111, 1112, 1163, 1164, 1210; ONTONAGON Co.: W. Patrick 1178; WASHTENAW Co.: F. Hoseney 818, 821.

5. *Helvella corium* (Weberb.) Massee, British Fungus-Flora 463. 1895.
Peziza corium Weberbauer, Pilze Norddeutschl. 1: 7. 1873.
Scypharia corium (Weberb.) Quél., Ench. Fung. 283. 1886.
Lachnea corium (Weberb.) Phill., Man. Brit. Disc. 204. 1887.
Macropodia corium (Weberb.) Sacc., Syll. Fung. 8: 159. 1889.
Fuckelina corium (Weberb.) O. Kuntze, Rev. Gen. Pl. 2: 852. 1891.
Sarcoscypha corium (Weberb.) Schroet. in Cohn, Krypt.-Fl. Schlesien 3: 59. 1893.
Cyathipodia corium (Weberb.) Boud., Hist. Class. Disc. d'Eur. 39. 1907.
Cowlesia corium (Weberb.) Nieuwl., Amer. Midl. Naturalist 4: 380. 1916.
Helvella nigra Peck, Bull. Torrey Bot. Club 26: 70. 1899. (Type at NYS examined).

Type: "In the Botanical Institute of Breslau" (Dissing, 1966).

Illustrations: Figs. 25, 26.

Apothecium 0.5-5.6(-9) cm broad, up to 3.7 cm high; when young compressed, cupulate; in age varying to plane or nearly so. Margin when young curving over the hymenium, spreading in age; edge entire or becoming

Fig. 25. *H. corium,* about natural size, N. J. Smith 1015 (photo by the author).

Fig. 26. *H. corium,* about natural size, N. J. Smith 1015 (photo by the author).

crenate or lobed in age. Hymenial surface dark brownish black to black, even to slightly rugose in the center. Sterile surface black or the vesture at the margin occasionally white, furfuraceous, even.

Stipe 1-3.7 cm long, 2-15 mm thick; terete to compressed, even or frequently with low irregular rounded ribs which do not continue onto the apothecium; black apically, often dingy gray at the base.

Spores (16.5-)17-20(-21) × 10.5-12.5 μ oblong to ellipsoid, with one large central oil droplet, smooth. Hymenium 150-430 μ thick. Paraphyses brown due to wall pigment; clavate to subcapitate, the clava 3.5-9 μ wide. Asci 8-spored, 14-16 μ wide.

Ectal excipulum of the apothecium 70-140(-250) μ thick; of *textura angularis* with individual hyphae and hyphal fascicles projecting irregularly along the outer surface; inner part hyaline, outer part with dark brown hyphal walls. Medullary excipulum 190-420 μ thick; of *textura intricata,* the hyphae 3.5-17.5 μ broad, hyaline. Ectal excipulum of the stipe 70-150 μ thick; of *textura angularis* with short fascicles of hyphae projecting along the outer edge; inner part hyaline, outer part with dark brown hyphal walls. Medullary excipulum of *textura intricata,* the hyphae hyaline, 3-5.5 μ broad.

The only known locality for *Helvella corium* in Michigan is an old mill yard in Marquette where the fungus fruited in June on sawdust-impregnated soil under aspen. This site has been built upon in recent years.

The uniform black coloration occasionally relieved by whitish marginal vesture, blunt rounded ribs on the stipe of large specimens, and early time of fruiting are usually sufficient to distinguish this species.

Material examined: ENGLAND: NORTH DEVON: Herb. Hort. Bot. Reg. Kew, 20 May 1951. U.S.A.: IDAHO: VALLEY Co.: A. H. Smith 44224, 44434, 44847, 45154; MICHIGAN: MARQUETTE Co.: A. H. Smith 66709; N. J. Smith 84, 85, 1015, 1016, 1026.

6. *Helvella queletii* Bresadola, Rev. Mycol. (Paris) 4: 211. 1822.
Type: Italy: Boss de lance sopra Terzolaj, May 1882, Bresadola (S).
Illustrations: Figs. 27, 28.

Apothecium 2-8(-12) cm broad; when young often compressed to trilobate, in age cupulate to plane or with reflexed lobes. Margin curving toward the hymenium to flaring in age; edge entire to irregularly lacerate in age. Hymenial surface grayish brown, "Olive Brown," "Buffy Brown," or "Mummy Brown"; even. Sterile surface of the apothecium concolorous with the hymenial surface or lighter especially toward the stipe, "Buffy Brown" to "Light Buff"; finely granulose; even.

Stipe 1-7(-12) cm long, 0.5-2(-5) cm thick; costate, the ribs rounded, branching and anastomosing on occasion, never extending onto the sterile surface of the apothecium; nearly white to "Light Buff" or tan; finely granulose to glabrous.

Spores (16.5-)18-21(-22.5) × 11.5-14 μ; oblong to ellipsoid; when fresh with one large central oil droplet and often 3-5 smaller droplets at each end, when revived in water with a single droplet; smooth. Hymenium 210-320 μ thick. Paraphyses hyaline to diffusely light brown; clavate, the clava 4-7 μ wide. Asci 8-spored, 14-16 μ wide.

Ectal excipulum of the apothecium 100-200 μ thick, of *textura angularis* with scattered hyphae and hyphal fascicles projecting along the outer edge; with light brown intracellular pigment in a few scattered cells. Medullary excipulum (100-)200-500 μ thick; of *textura intricata,* the hyphae 3-5(-11) μ broad, hyaline, many refractive in KOH. Ectal excipulum of the stipe 50-350 μ thick; of *textura angularis* with scattered cells and hyphae projecting along the outer edge. Medullary excipulum of *textura intricata,* the hyphae hyaline, refractive, 2-4 μ broad.

Fig. 27. *H. queletii,* ×1, N. J. Smith 2208.

Fig. 28. *H. queletii,* ×1, A. H. Smith 75465.

In Michigan, *Helvella queletii* is typically scattered to gregarious on well drained soil under hardwood, although N. J. Smith 2208 was found in a wet area under white cedar. Elsewhere, it is reported to be terrestrial and usually under hardwoods, rarely conifers. It fruits from May to July in Michigan.

The typically dark brown hymenial surface with the pale ribbed stipe and even sterile surface on the apothecium distinguish this species from other members of the genus. Two intergrading variants of this species have been noted. One is characterized by a thin (up to 3 mm thick), solid stipe with only a few low unbranched ribs (see N. J. Smith 2208 and the material from Washington). The other variant has a broader stipe (up to 4 cm thick) which is often lacunose in cross section and whose ribs are usually sharp-edged and branching (see Wells and Kempton 8/17/61-1, Trueblood 2166, Smith 75465). The thin form occurs primarily in wet or boggy areas whereas the thick one is apparently characteristic of drier habitats.

Helvella queletii is placed in Section *Macropodes* rather than Section *Acetabulum* because the low rounded ribs described for *H. queletii* (see photograph of the type in Dissing, 1966) are more like those of *H. corium* than those of *H. acetabulum.* However, robust specimens of *H. queletii* may exhibit ribbing reminiscent of that found in *H. acetabulum,* and the color difference between the stipe and apothecium in *H. queletii* is also similar to that in Section *Acetabulum. H. queletii* is intermediate in rib morphology and coloration between Section *Acetabulum* and Section *Macropodes,* and its position in the classification will likely remain debatable for some time to come.

Material examined: CANADA: BRITISH COLUMBIA: K. Harrison 6061; NOVA SCOTIA: K. Harrison 7623, 7648. U.S.A.: ALABAMA: LEE Co.: A. H. Povah 6 Nov. 1922; ALASKA: V. Wells and P. Kempton 8/17/68-1; CALIFORNIA: SANTA BARBARA Co.: P. M. Rea 1939; IDAHO: OWYHEE Co.: E. Trueblood 2166, 2174; VALLEY Co.: A. H. Smith 65336; MICHIGAN: ALGER Co.: A. H. Smith 75465; CHEBOYGAN Co.: A. H. Smith 25356; N. J. Smith 2177, 2183, 2208; EMMET Co.: A. H. Smith 32-112; N. J. Smith 148; KEWEENAW Co.: J. L. Lowe Fl. 92; A. H. Povah Fp. 161; GRATIOT Co.: V. Potter 4591, 4905, 5107, 9602; LIVINGSTON Co.: R. Zehner 174; MARQUETTE Co.: E. B. and E. E. Mains 33-336; OAKLAND Co.: A. H. Smith 18350; WASHTENAW Co.: L. N. Johnson 9 June 1894; C. H. Kauffman 24 June 1905; A. H. Smith 18 June 1930, 20420, 20422, 20427; N. J. Smith 968, 969, 981; TEXAS: J. Dean 18 Mar. 1966; WASHINGTON: CLALLAM Co.: A. H. Smith 14016, 14282; GRAYS HARBOR Co.: A. H. Smith 13489, 13553; PIERCE Co.: Imshaug 867; Simmons 1637; A. H. Smith 28941, 30031; WYOMING: ALBANY Co.: B. B. Kanouse 5 Sept. 1923.

7. *Helvella* **pallidula** sp. nov.

Type: Michigan Montmorency Co.: Scattered on sandy soil in a deciduous woods, northwest corner, 24 July 1967, N. J. Smith 397 (MICH).

Illustration: Fig. 7.

Apothecium 0.7-2.3 cm latum, usque 1 cm profundum, cupulatum, compressum vel regulare. Hymenium prope "Pinkish Buff" vel dilute cinereo-brunneum, planum. Pagina sterilis colorata similis hymenio, plana pubescens vel villosa. Margo integer, curvus vel rectus. Stipes 0.5-3.5 cm longus, 1-4 mm crassus, teres, aequalis vel sursum attenuatus, coloratus similis paginae sterili vel deorsum dilutus.

Sporae (15.5-)16.5-19(-21) × 10.5-12 μ, ellipsoidae ad oblongae. Hymenium 200-300 μ crassum. Paraphyses 3 μ crassae, apice usque 5-10 μ clavato-incrassatae, hyalinae. Asci 14-15 μ crassi. Excipulum 100-160 μ crassum, texturae angularis cum fasciculis hypharum projectio secus marginem; hyalinum. Medulla 100-400 μ crassa, texturae intricatae, hyphae hyalinae.

Specimen typicum in Herb. Univ. Mich. conservatum est; sub silvis frondiferis, northwest corner, Montmorency Co., Michigan, 24 July 1967, leg. N. J. Smith 397.

Apothecium 0.7-2.3 cm broad, up to 1 cm deep; cupulate, compressed, or regular. Margin when young curved over the hymenium, in age typically straight; edge entire. Hymenial surface near "Pinkish Buff" to pale gray-brown; even. Sterile surface concolorous with hymenial surface, villose especially near the margin, even.

Stipe 0.5-3.5 cm long, 1-4 mm thick; terete, even, equal or tapering toward the apex; concolorous with the sterile surface of the apothecium to paler near the base; villose.

Spores (15.5-)16.5-19.5(-21) × 10.5-12.5 μ; oblong to ellipsoid; when fresh with one large central oil droplet and 0-5 smaller droplets at each end, when revived in water with only one droplet; smooth or verrucose-rugulose; Hymenium 200-300 μ thick. Paraphyses hyaline; clavate, the clava 5-10.5 μ broad. Asci 8-spored, 14-16 μ broad.

Ectal excipulum of the apothecium 100-160 μ thick, of *textura angularis* with hyphal fascicles projecting along the outer edge, hyaline to pale tan but lacking localized pigmentation. Medullary excipulum 100-400 μ thick; of *textura intricata,* the hyphae 3.5-17.5 μ broad, hyaline. Ectal excipulum of the stipe 140-230 μ thick, of *textura angularis* with hyphal fascicles projecting along the outer edge, hyaline. Medullary excipulum of *textura intricata,* the hyphae hyaline, 2-5 μ broad.

Scattered to gregarious on sandy soil under hardwoods. It fruits from the middle of summer through the fall.

Helvella pallidula is unique in Section *Macropodes* in lacking any type of localized pigmentation in the tissues of the ascocarp. It represents one extreme in the section in its lack of pigment. This characteristic is associated with relatively pale tan to pale drab colors in the entire ascocarp.

Material examined: DENMARK: SJAELLAND: M. Lange 21 Aug. 1960 (C). U.S.A.: MICHIGAN: EMMET Co.: A. H. Smith 75751; N. J. Smith 413; GRATIOT Co.: V. Potter 10235, 10665; MONTMORENCY Co.: N. J. Smith 397, 419; ONTONAGON Co.: W. Patrick 1273.

8. *Helvella villosa* (O. Kuntze) Dissing & Nannfeldt, Svensk Bot. Tidskr. 60: 330. 1966.

Fuckelina villosa O. Kuntze, Rev. Gen. Pl. 2: 851. 1891.

Cyathipodia villosa (O. Kuntze) Boud., Hist. Class. Disc. d'Eur. 39. 1907.

Type: Tab. 19, Fig. B, No. 3 in Hedwig, Species Muscorum Frond. 2: 54. 1788. (Dissing & Nannfeldt, 1966).

Illustration: Fig. 29.

Apothecium 1-2.5(-4) cm broad, up to 1.5 cm high if cupulate; typically saucer-shaped to plane or slightly recurved. Margin when young inclined toward the hymenium, in age straight; edge entire or in age becoming irregularly lacerate. Hymenial surface when young near "Fuscous Black," in age "Mouse Gray," "Smoke Gray," to "Drab Gray"; even. Sterile surface of the apothecium nearly concolorous with the hymenial surface, "Fuscous" to "Drab" or "Clove Brown"; villose; even.

Stipe 1-4 cm long, 1.5-5 mm thick; terete and even to compressed, in age sometimes cleft-pitted basally, tapering toward the apex; concolorous with the sterile surface apically, often paler ("Light Buff") at the base; villose apically to roughened at the base.

Spores (16-) 17-20 × 10.5-12(-13.5) μ; oblong to ellipsoid; with one large oil droplet and 0-5 small droplets at each end when fresh, when revived in water with a single droplet; smooth or occasionally verrucose-rugulose or verruculose. Hymenium 224-300 μ thick. Paraphyses hyaline to pale tan; clavate, the clava 5-10 μ broad. Asci 8-spored, 14-17 μ broad.

Ectal excipulum of the apothecium 100-200 μ thick, of *textura angularis* with individual hyphae and hyphal fascicles projecting along the outer edge, with areas of brown wall material on some cells. Medullary excipulum 100-200(-500) μ thick; of *textura intricata,* the hyphae 3-10(25) μ broad, some hyaline, others with areas of brown wall material. Ectal excipulum of the stipe 100-300 μ thick; of *textura angularis* with individual hyphae and hyphal fascicles projecting irregularly along the outer edge; with some hyaline cells, others with light gray-brown wall pigment. Medullary excipulum of *textura intricata,* the hyphae 2.5-5 μ broad, hyaline or with areas of brown wall material near the excipulum.

Scattered on sandy soil in damp woods and along streams under hardwoods. It fruits from early summer to fall in Michigan. In Denmark, it is found along roadsides, and in Idaho, it fruited in river overflow areas.

Fig. 29. *H. villosa,* ×1, N. J. Smith 2099.

Helvella villosa can be separated from other species in this section by the combination of ellipsoid to oblong spores and brown wall pigments on at least some hyphae in the apothecium. It has the truest gray colors of all species in this section; however, color alone is seldom sufficient to distinguish the species. Unlike the closely related *H. cupuliformis*, *H. villosa* has a stipe typically concolorous with the sterile surface of the apothecium, and, if paler at all, grayish white at the base. In *H. cupuliformis*, the colors tend toward creamy to grayish brown.

The characters used to separate *Helvella villosa* and *H. cupuliformis* are the type and location of the pigment in the tissues of the apothecium. The distinction may not be a valid one, but the characters are constant within a collection and do not vary with age. The problem of the significance of the type and location of pigment in the tissues of the apothecium has also been encountered in Section *Acetabulum*.

Through the courtesy of the Botanical Museum of the University of Copenhagen, Danish material identified as *Helvella villosa* by Henry Dissing was examined. Dissing and Nannfeldt (1966) described the taxon and transferred it to *Helvella;* the material on which that description was based was not included in my loan. However, in the material examined, some collections had the cytoplasmic pigment characteristic of *H. cupuliformis*, some had brown hyphal walls, and one collection lacked both types of pigment. The problem arose of just what was the original concept of *H. villosa*. The illustration chosen by Dissing and Nannfeldt as lectotype and its accompanying description lack information on the anatomical features of the taxon. A choice had to be made whether to follow the stated concept of *H. villosa* by Dissing and Nannfeldt or whether to ignore the name and describe a new taxon. Since specimens agreeing with Dissing and Nannfeldt's concept of *H. villosa* were known, I follow their lead and limit the species to specimens with brown wall pigment. All specimens lacking this character are referred either to *H. cupuliformis* or to *H. pallidula*.

Material examined: DENMARK: SJAELLAND: H. Dissing 7 Sept. 1960, 61.171, 64.211, 65.42, 10 Aug. 1970 (in two parts, one freeze-dried), 18 Aug. 1970 (C). U.S.A.: IDAHO: BONNER Co.: N. J. Smith 2002, 2099, 2100, 2101; IDAHO Co.: A. H. Smith 70096; MICHIGAN: EMMET Co.: N. J. Smith 2302, 2354, 2394, 2396, 2397, 2398, 2416; LIVINGSTON Co.: A. H. Smith 30 July 1970; WASHTENAW Co.: C. Nimke 31 July 1970; A. H. Smith 78375, 78376; N. S. Weber 2447, 2455, 2464.

9. *Helvella cupuliformis* Dissing & Nannfeldt, Svensk Bot. Tidskr. 60: 326. 1966.

Type: Sweden: Uppland: Uppsala, near Kåbo, in dense coniferous forest, on bare soil, under *Abies* sp., 30 July 1936, K. G. Ridelius (UPS).

Apothecium 5-20 mm broad, saucer-shaped to plane, compressed to regular. Margin straight or inclined toward the hymenium when young; edge entire or in age irregularly lacerate. Hymenial surface drab to light grayish brown. Sterile surface of the apothecium paler than the hymenial surface, lightest around the stipe apex; densely villose; even.

Stipe 8-15 mm long, 1.5-4 mm thick; terete and even or rarely with low rounded ribs, tapering slightly toward the apex; light ochraceous tan to light

drab, typically paler than the sterile surface of the apothecium; villose to pubescent.

Spores (16-)17-19 × (10-)11-12 μ, when revived in water with a single oil droplet, smooth or verrucose-rugulose. Hymenium 200-260(-300) μ thick. Paraphyses hyaline; clavate, the clava 5-8 μ broad. Asci 8-spored, 14-16 μ broad.

Ectal excipulum of the apothecium 90-180 μ thick; of *textura angularis* with individual hyphae and hyphal fascicles projecting along the outer edge; the outer part mostly hyaline, some cells in the inner part with light brown cell content either diffuse in the cell or coagulated in revived material as seen in KOH or lactic acid. Medullary excipulum 100-300(-500) μ thick; of *textura intricata,* the hyphae hyaline, 3-10 μ broad. Ectal excipulum of the stipe 90-300 μ thick, of *textura angularis* with hyphae and hyphal fascicles projecting along the outer edge, hyaline or some cells near the medullary excipulum with ochraceous brown intracellular pigmentation. Medullary excipulum of *textura intricata,* the hyphae hyaline, 2.5-4 μ broad.

Scattered to gregarious on sandy soil under hardwoods in Michigan. It fruits from summer into fall.

Helvella cupuliformis resembles *H. queletii* in ascocarp color as noted by Dissing and Nannfeldt (1966). It is distinguished from *H. queletii* by its terete to indistinctly ribbed stipe and generally smaller size. *H. cupuliformis* has browner tones and intracellular pigment in contrast to the grayer tones and wall pigments of *H. villosa* (see discussion of *H. villosa*). In addition, the sterile surface of the apothecium in *H. cupuliformis* typically is lighter around the stipe apex whereas in *H. villosa* it is typically uniform in color.

The pattern of pigmentation in the tissues of the apothecium attributed here to *Helvella cupuliformis* was observed in the type collection and is thought to be a reliable character. In material from C, some collections of *H. cupuliformis* were found in material identified as *H. villosa,* including the collection whose photograph was published as *H. villosa* by Dissing and Nannfeldt (1966).

Material examined: DENMARK: JYLLAND: P. M. Petersen S712 (C); SJAELLAND: H. Dissing 17 Aug. 1961, 61.150 (C); K. Toft 28 Oct. 1967 (C). SWEDEN: UPPLAND: K. G. Ridelius 30 July 1936 (UPS). U.S.A.: MICHIGAN: BARRY Co.: Mycol. Soc. Am. Foray 3 Sept. 1955; CHEBOYGAN Co.: A. H. Smith 25894; LIVINGSTON Co.: A. H. Smith 78469; OAKLAND Co.: A. H. Smith 6476; WASHTENAW Co.: A. H. Smith 78380; N. S. Weber 2465.

Section *Ephippium* Dissing, Dansk Bot. Ark. 25: 114. 1966.
Type species: *Helvella ephippium.*

Apothecium deflexed, saddle-shaped to trilobate. Margin when young partially obscuring the hymenium to straight, variously curved to flaring in age. Hymenial surface dark grayish brown to black, rarely drab gray; even. Sterile surface of the apothecium glabrous, roughened or villose to pruinose; even. Stipe terete to compressed, occasionally cleft-pitted at the base; dark grayish brown to black, rarely drab; roughened to villose. Asci pleurorhynchous.

Three species known from Michigan.

10. *Helvella ephippium* Léveillé, Ann. Sci. Nat. Bot. Ser. 2, 16: 240. 1841.

Leptopodia ephippium (Lev.) Boud., Hist. Class. Disc. d'Eur. 37. 1907. Type: "Not available" (Dissing, 1966).

Apothecium 1.5-2 cm high, 1.4-2 cm broad, saddle-shaped to trilobate to nearly saucer-shaped. Margin flaring or inclined over the hymenial surface; edge entire or irregularly lacerate in age, free. Hymenial surface near brownish mouse gray to "Light Drab," even. Sterile surface of the apothecium concolorous with the hymenial surface or slightly paler, densely villose, even.

Stipe 1.5-2.5 cm long, 2-5 mm thick; terete to compressed, even, tapering toward the apex; concolorous with the sterile surface of the apothecium or lighter at the base; villose.

Spores 16.5-19 X 10.5-12 μ; broadly ellipsoid; when fresh containing one large oil droplet and 0-3 small droplets at each end, when revived in water with a single large droplet; smooth or occasionally verrucose-rugulose. Hymenium 210-280 μ thick. Paraphyses hyaline to pale tan due to wall pigment; clavate, the clava 4-7 μ broad. Asci 8-spored, 14-16 μ broad.

Ectal excipulum of the apothecium 105-157 μ thick, of *textura angularis* with numerous fascicles of hyphae projecting along the outer edge, hyaline to diffusely pale tan. Medullary excipulum 100-350 μ thick; of *textura intricata,* the hyphae predominantly hyaline, a few with patches of light brown wall pigment, 3.5-10.5 μ broad. Ectal excipulum of the stipe 140-175 μ thick, of *textura angularis* with hyphae and hyphal fascicles projecting along the outer edge, hyaline to pale tan. Medullary excipulum of *textura intricata,* the hyphae hyaline, 3-6 μ broad.

Solitary to gregarious on sandy soil along old roads under hardwoods. It fruits in July and August in Michigan.

Helvella ephippium is distinguished from *H. atra* and *H. subglabra* by the villose sterile surface of the apothecium. It can not be as easily separated from *H. pezizoides.* In *H. ephippium* the colors are grayer and lighter, often with a slight olivaceous cast, the villosity more conspicuous and the ascocarps smaller than in *H. pezizoides.*

Material examined: MICHIGAN: EMMET Co.: H. Thiers 4128; MARQUETTE Co.: N. J. Smith 1260, 1430

11. *Helvella pezizoides* Fries, Systema Mycologicum 2: 20. 1822.

Leptopodia pezizoides (Fr.) Boud., Hist. Class. Disc. d'Eur. 37. 1907.

Type: Pl. 10, Fig. 2 in Afzelius, Kong. Vetensk. Acad. Nya Handl. 4: 308. 1783 (Dissing, 1966).

Illustrations: Figs. 30, 31.

Apothecium 1.5-4(-5.5) cm high, 1.5-4(-5.5) cm broad; saddle-shaped with ascending lobes typically forming an acute sinus in mature specimens. Margin when young curving over the hymenial surface but not obscuring it, expanding in age to flaring, the lobes of the apothecium then appearing appressed against the stipe; edge entire or rarely lacerate. Hymenial surface drab gray to dark brownish gray or rarely dingy drab, even. Sterile surface of the apothecium typically slightly paler than the hymenial surface, pubsecent to villose, even, in age frequently ingrown with other parts of the ascocarp.

Fig. 30. *H. pezizoides,* ×1, N. J. Smith 443.

Fig. 31. *H. pezizoides,* ×1, N. J. Smith 2234.

Stipe 3-4(-8) cm long, 3-10(-20) mm thick; terete to compressed, even or frequently with shallow pits near the base in larger specimens, tapering toward the apex; concolorous with the sterile surface of the apothecium to lighter at the base; pruinose to villose.

Spores 17-20 X 10.5-12 μ, oblong to ellipsoid, when revived in water with a single large oil droplet, smooth or rarely verrucose-rugulose. Hymenium 225-280 μ thick. Paraphyses hyaline to pale tan due to wall pigment; clavate, the clava 4-8(-10) μ broad. Asci 8-spored, 14-16 μ broad.

Ectal excipulum of the apothecium 85-150 μ thick; of *textura angularis* with scattered to numerous hyphae and hyphal fascicles projecting along the outer edge; with brown walls on the cells in the inner part, end cells typically hyaline. Medullary excipulum 80-280 μ thick; of *textura intricata,* the hyphae 3.5-10.5 μ broad, hyaline or with patches of brown wall material near the margin and along the ectal excipulum. Ectal excipulum of the stipe 122-300 μ thick, of *textura angularis* with numerous hyphae and hyphal fascicles projecting along the outer edge, with scattered cells with brown wall material. Medullary excipulum of *textura intricata,* the hyphae 3.5-6 μ broad, predominantly hyaline, scattered hyphae near the ectal excipulum with patches of brown wall material.

Scattered to gregarious on hardwood debris or terrestrial. It fruits from July to September in Michigan.

Helvella pezizoides is intermediate between *H. ephippium* and *H. subglabra* in color, habitat, and vesture. *H. pezizoides* is not uncommon on humus and rotting wood in the Tahquamenon area of Michigan. Specimens from that area are definitely pubescent to villose on the sterile surface of the apothecium when young, the margin curves over the hymenium but does not obscure it, and the lobes of the apothecium form an acute sinus. The characters used to delimit the taxon are constant in dried material and constant between young and old material although the vesture seems to be less conspicuous in age.

Material examined: MICHIGAN: CHIPPEWA Co.: A. H. Smith 75998, 75999; N. J. Smith 443, 560; LIVINGSTON Co.: A. H. Smith 78578; LUCE Co.: A. H. Smith 38015, 38069, 38652, 39617, 39623; N. J. Smith 665, 666, 673, 2334; H. Thiers 4093; WASHTENAW Co.: A. H. Smith 78382; NEW YORK; ESSEX Co.: A. H. Smith 526, 539.

12. *Helvella atra* Fries, Systema Mycologicum 2: 19. 1822.

Leptopodia atra (Fr.) Boud., Hist. Class. Disc. d'Eur. 37. 1907.

Type: Tab. 25, Holmskjold, Beata ruris otia Fungis Danicis. 1799. (Dissing, 1966).

Apothecium 0.7-2 cm high, 0.7-2 cm broad; saddle-shaped to trilobate with ascending lobes forming a narrow sinus. Margin flaring to inclined over the hymenium, occasionally ingrown with the stipe; edge entire, often nearly white when dry (as in *H. corium*). Hymenial surface black or rarely drab when young, jet black in age; even. Sterile surface of the apothecium drab gray to blackish, glabrous, even, free or ingrown with other parts of the ascocarp.

Stipe 1-3 cm long, 2-5 mm thick; terete to compressed, even or occasion-

ally shallowly pitted at the base; drab near the base, blackish at the apex; glabrous to finely roughened.

Spores 17.5-20 X 11-12.5 μ, oblong to ellipsoid, when revived in water with one large central oil droplet, smooth. Hymenium 210-300 μ thick. Paraphyses dark umber brown in mass due to wall pigments; clavate, the clava 5-8(-10) μ broad. Asci 8-spored, 14-16 μ broad.

Ectal excipulum of the apothecium 70-140 μ thick, of *textura angularis* with a palisade of clavate hyphal end-cells along the outer edge, with brown walls on the hyphal cells particularly near the margin where some cells may be dead and have hyaline internal and/or external deposits. Medullary excipulum (70-)200-300 μ thick; of *textura intricata,* the hyphae 3.5-17.5 μ broad, hyaline or with patches of brown wall material. Ectal excipulum of the stipe 100-400 μ thick, of *textura angularis* with scattered hyphae and hyphal fascicles projecting along the outer edge, dark brown due to brown wall material. Medullary excipulum of *textura intricata,* the hyphae hyaline, 3.5-10 μ broad.

Scattered to gregarious on soil under *Pinus ponderosa* in the fall. It is known from New Mexico only so far in this country.

Helvella atra is included in this paper because it has been reported from Michgian (Dissing, 1966); however, no Michigan material I have studied can be assigned to this taxon if Dissing's concept of *H. atra* is strictly interpreted. Dr. Kenneth Harrison found two sizeable collections of a jet black *Helvella* in New Mexico which fit the European concept of *H. atra.* The sterile surface of the apothecium in his material is truly glabrous, the cells in the excipulum of the apothecium have brown walls, and the medullary excipulum hyphae are predominantly hyaline. These observations are consistent with Dissing's description of *H. atra* (Holmskjold and Fries did not include data on the anatomical features of this species). In contrast, the Michigan material may be glabrous in age, but frequently has individual cells and hyphae projecting on the sterile surface of the apothecium when young. In addition, only a few scattered cells in the ectal excipulum have brown walls and then the wall material is broken up, and many hyphae in the medullary excipulum have brown walls. Furthermore, in comparison with the New Mexico material, the Michigan specimens are not black. Thus, *H. atra* has not been recognized from Michigan here, and the material from this state is considered under either *H. subglabra* or *H. pezizoides.*

Material examined: NEW MEXICO: LOS ALAMOS Co.: K. Harrison 7133, 7163.

13. *Helvella* **subglabra** sp. nov.

Type: Michigan: Washtenaw Co.: Stinchfield Woods, near Dexter, 13 Oct. 1968, N. J. Smith 2145 (MICH).

Illustrations: Figs. 8, 32, 33.

Apothecium 0.8-2.6 cm altum, 0.8-2.6 cm latum, deflexum vel lobatum, lobis ascendibus. Hymenium fuligineo-nigrum vel sordido-cinereum, planum. Pagina sterilis colorata similis hymenio vel dilutior, pruinosa vel impolita, aequata, libra vel conjuncta stipite. Margo rectus vel revolutus, liber vel revolutus, liber vel stipiti adherens. Stipes 2-5.5 cm longus, 2-6 mm crassus;

Fig. 32. *H. subglabra,* ×1, N. J. Smith 2223, dark form.

Fig. 33. *H. subglabra,* ×1, N. J. Smith 1336, typical form.

teres vel compressus, sursum attenuatus; pruinosus; cinereus, deorsum subalbidus.

Sporae 17-19.5 × 10.5-12 μ, ellipsoidae vel oblongae. Hymenium 230-300 μ crassum. Paraphyses 3 μ crassae, apice ad 5-9 μ clavato-incrassatae; hyalinae vel infuscatae. Excipulum 80-140 μ crassum, vallum cellularum hypharum cum vel sine hyphis sparsis projectis vel hyphis cellularum; paries hypharum hyalinus vel fuscus. Medulla 120-245 μ crassa, texturae intricatae, paries hypharum hyalinus vel fuscus.

Specimen typicum in Herb. Univ. Mich. conservatum est; Stinchfield Woods prope Dexter, Michigan, 13 October 1968, leg. N. J. Smith 2145.

Apothecium 0.8-2.6 cm high, 0.8-2.6 cm broad, saddle-shaped to trilobate with slightly to sharply ascending lobes forming an acute to obtuse sinus. Hymenial surface dark gray to nearly black when young, gray to dark gray in age; even. Sterile surface of the apothecium concolorous with the hymenial surface to paler; finely pruinose; even; free when young, frequently becoming ingrown with the stipe or apothecium in age. Margin flaring when young, remaining that way or curving toward the stipe and causing the lobes of the apothecium to curve convexly in age.

Stipe 2-5.5 cm long, 2-6 mm thick; when young terete, even, tapering toward the apex, in age often irregularly compressed with shallow pits at the base; dark gray to drab with a whitish base; pruinose.

Spores (15-)17-19.5 × 10.5-12 μ, ellipsoid to oblong, with one large oil droplet when fresh and 0-5 smaller droplets at each end of the spore, with a single droplet when revived in water; smooth or verrucose-rugulose. Hymenium 230-280 μ thick. Paraphyses hyaline to brown in mass; clavate, the clava 5-9 μ broad. Asci 8-spored, 14-15 μ broad.

Ectal excipulum of the apothecium 80-140 μ thick; a palisade of hyphal end-cells with scattered projecting hyphae or hyphal cells along the outer edge; with some hyaline cells, others with light brown walls. Medullary excipulum 120-245 μ thick; of *textura intricata,* the hyphae 3.5-15 μ broad, hyaline or with light brown wall material. Extal excipulum of the stipe 190-210 μ thick; of *textura angularis* with scattered projecting hyphae and hyphal cells along the outer edge; with some cells hyaline, others with brown walls. Medullary excipulum of *textura intricata,* some hyphae hyaline, others with brown walls near the ectal excipulum.

Solitary to gregarious, often on woody debris but also on damp soil, especially under white cedar. The type collection was terrestrial in a damp area under white cedar. It fruits from July to October in Michigan.

Helvella subglabra can be distinguished from *H. pezizoides* by the sparse vesture on the sterile surface of the apothecium which may wear away by maturity, the convex lobes of the apothecium at maturity with often only a shallow sinus, and the flaring margin (see discussion of *H. atra*).

Several collections have been studied in which the marginal curvature is similar to that described for *H. pezizoides,* but the sterile surface of the apothecium is nearly glabrous as in *H. subglabra.* The apothecium is often deflexed with a broad sinus and the hymenium dark gray in such material.

Many of these collections are single specimens so it is difficult to assess variation in the group. (See A. H. Smith 21911, 21961, 33034, 49829, 75968; N. J. Smith 261, 301, 564; and I. Bartelli 3143 for examples of this group.)

Material examined: MICHIGAN: ALGER Co.: N. J. Smith 564; CHEBOYGAN Co.: A. H. Smith 21911, 21961, 75968, 65009; N. J. Smith 268, 2216, 2223, 2239; EMMET Co.: C. H. Kauffman 14 Sept. 1932; E. B. MAINS 32-769; A. H. Smith 49829; N. J. SMITH 261, 301; JACKSON Co.: A. H. Smith 78412; KEWEENAW Co.: J. L. Lowe & A. H. Povah Fp. 258, 636; LIVINGSTON Co.: A. H. Smith 78479; MACKINAC Co.: A. H. Smith 33034; MARQUETTE Co.: I. Bartelli 3143; C. H. Kauffman 23 Aug. 1909; A. H. Smith 78593; N. J. Smith 1359, 1424, 1506; N. S. Weber 2469, 2475, 2476, 2480, 2490; WASHTENAW Co.: N. J. Smith 2145; N. S. Weber 2461.

Section *Lacunosae* Dissing, Dansk Bot. Ark. 25: 98. 1966.
Type species: *Helvella lacunosa.*

Apothecium mitrate, saddle-shaped, lobed, or hemispheric to convex at maturity. Margin variable, but not rolled over the hymenium when young. Hymenial surface gray to black, drab or nearly white; wrinkled or even. Sterile surface of the apothecium unpolished, glabrous. Stipe costate, glabrous, lacunose or solid. Asci pleurorhynchous.

Four species known from Michigan.

14. *Helvella phlebophora* Pat. & Doass. in Pat., Tab. Anal. Fung. 5: 208. 1883.

Globopilea phlebophora (Pat. & Doass.) Beauseig., Contr. Etude Fl. Mycol. Landes 204. 1926.

Type: Unknown (Dissing, 1966).
Illustration: Fig. 34.

Apothecium 5-14 mm high, 10-30 mm broad, convex to hemispheric, rarely slightly compressed. Margin when young straight to curved toward the stipe, in age straight or spreading; edge entire or lacerate in age. Hymenial surface gray, "Hair Brown" when young to "Pale Smoke Gray" in age; even or with broad low radiating ridges. Sterile surface of the apothecium lighter gray than the hymenial surface; glabrous; ribbed with distinct simple to forked ribs which often resemble lamellae, up to 1 mm thick and 4 mm broad near the stipe apex, tapering toward the margin, concolorous with or paler than the sterile surface; when young free of the stipe, in age free or rarely ingrown with the stipe near the apothecial margin.

Stipe 1-5 cm long, 2-6 mm thick; equal or tapering toward the base; costate with 3-5 rounded to sharp edged ribs, ribs continuing onto the sterile surface of the apothecium; solid; concolorous with or paler than the hymenial surface.

Spores (15-) 16-17.5 × 11-12 μ, ellipsoid, with one oil droplet, smooth. Hymenium 230-280 μ thick. Paraphyses hyaline to light grayish brown, the pigment in the hyphal walls; narrowly clavate, the clava 5-8 μ wide. Asci 8-spored, 12-15 μ wide.

Ectal excipulum of the apothecium 50-80(-100) μ thick; of a palisade of clavate hyphal end cells and 1-3 layers of subtending compacted cells; hyaline to brownish gray, the pigment in the hyphal walls. Medullary excipulum

Fig. 34. *H. phlebophora,* ×1, E. B. Mains 33-558.

50-300 μ thick; of *textura intricata;* the hyphae hyaline, clear or refractive, 2.5-3 μ wide (to 10 μ near the hymenium). Ectal excipulum of the stipe 80-260 μ thick, of *textura angularis* with a palisade of clavate hyphal end cells forming the outer surface, hyaline to light grayish brown due to wall pigmentation. Medullary excipulum of *textura intricata;* the hyphae hyaline, clear or refractive, 2.5-4 μ wide.

Scattered in damp mossy areas or along streams under conifers, particularly white cedar. It fruits in August to October in Michigan.

Helvella phlebophora can be recognized by the combination of hemispheric to convex apothecium with radiating ribs on the sterile surface, relatively small size and true gray colors. According to Dissing (1966) only a few collections of this species have been made in Europe where it is known only from France and Switzerland. The Michigan material extends the known range of the species to a new continent and is an interesting and significant addition to the Michigan fungus flora.

Material examined: MICHIGAN: EMMET Co.: A. H. Smith 77942; N. J. Smith 2378; LUCE Co.: E. B. Mains 33-558; MARQUETTE Co.: N. J. Smith 1962.

15. *Helvella sulcata* Fries, Systema Mycologicum 2: 15. 1822.
Type: Unknown.
Illustrations: Figs. 13, 35, 36, 37.

Apothecium 1-6(-18) cm high, 0.5-5(-14) cm broad, saddle-shaped with a shallow to acute sinus or trilobate. Margin when young free, straight or curving toward or away from the stipe; in age ingrown with the stipe or

apothecium, straight to spreading; edge entire when young, in age entire or irregularly lacerate. Hymenial surface pale drab gray to black, even or occasionally slightly wrinkled at the sinus. Sterile surface of the apothecium pale drab gray to dark gray, lighter than the hymenial surface; glabrous; even; when young free, in age ingrown with the stipe and/or parts of the apothecium.

Stipe 1.5-6(-15) cm long, 0.5-2(-3) cm thick; equal to subventricose; costate, the ribs pleat-like and single-edged to low, cord-like and double-edged, branching and anastomosing; occasionally internally lacunose near the base, seldom externally lacunose; pale to dark gray or drab gray.

Spores (14-)15.5-18 × 10.5-12.5 μ, ellipsoid, with one oil droplet, smooth. Hymenium 200-300 μ thick. Paraphyses hyaline to light brown, the pigment in the hyphal walls; clavate, the clava 4-8(-11) μ wide. Asci 8-spored, 14-16 μ wide.

Ectal excipulum of the apothecium 50-70(-125) μ thick; of a palisade of clavate hyphal end cells, with some cells hyaline, others with a continuous to irregularly ruptured light brown wall. Medullary excipulum 100-350(-400) μ thick; of *textura intricata,* the hyphae 3.5-7(-14) μ wide, hyaline or rarely with an irregularly ruptured brown wall, clear or refractive. Ectal excipulum of the stipe 40-260 μ thick, of *textura angularis* with a palisade of clavate hyphal end cells at the outer edge, hyaline to light brown due to wall pigmentation. Medullary excipulum of *textura intricata,* the hyphae hyaline, clear, or refractive, 2.5-5 μ wide.

Solitary to gregarious, terrestrial or more frequently on rotting hardwood debris, but occasionally in mixed woods or on conifer debris. It fruits from June to October in Michigan in relatively wet as well as relatively dry habitats.

Helvella sulcata can be recognized by the combination of the saddle-shaped to trilobate even apothecium, the lack of ribs on the sterile surface of the apothecium, and the preference for upland rather than boggy habitats.

Two main variants of *Helvella sulcata,* connected by a series of intermediates, are known from Michigan. The two groups are united in their

Fig. 35. *H. sulcata,* ×1, N. J. Smith 984, early season form.

Fig. 36. *H. sulcata,* ×1, N. J. Smith 1389, middle season form (photo by the author).

Fig. 37. *H. sulcata,* ×1, A. H. Smith 75904, late season pale form (extreme example).

basic form, size and shape of the ascocarp, size of spores, and other anatomic and morphologic features and they differ in season of fruiting, color, and somewhat in stature.

The first variant typically fruits early in the season from June 10 in southern Michigan to as late as August 20 in the northern Lower Peninsula. The apothecium is compressed with a narrow, nearly closed sinus, black hymenial surface, gray to drab stipe and scattered paraphyses and excipular cells have brown walls. The ascocarps are usually terrestrial.

The second variant fruits from about July 25 to October or the arrival of freezing weather. It has a broad sinus on the apothecium and often slightly convex sides, a pale gray to drab hymenial surface and stipe, and hyaline tissues. The ascocarps are usually lignicolous. Numerous collections intermediate in one or more respects between these groups have been found.

Material examined: CANADA: BRITISH COLUMBIA: K. Harrison 6 July 1966, 7 July 1966. U.S.A.: MICHIGAN: Alger Co.: E. B. Mains 32-712; A. H. Smith 20 Sept. 1929; ALLEGAN Co.: C. H. Kauffman 12 Sept. 1910; BARRY Co.: A. H. Smith 78351, 78352, 78353; CHEBOYGAN Co.: T. E. Brooks 999, 1002; M. V. Charlton G194; H. Imshaug 3325; J. Martinson 29 July 1965; A. H. Smith 22177, 75292, 75353, 75904; N. J. Smith 45, 56, 984, 1006, 1011, 2175, 2206, 2241, 2242, 2243, 2252, 2253, 2285; CHIPPEWA Co.: A. H. Smith 76002; N. J. Smith 633, 644, 647; CRAWFORD Co.: H. D. Thiers 3447; EMMET Co.: R. L. Shaffer 3994; GRATIOT Co.: V. Potter 4152, 9834, 9659, 9947; KEWEENAW Co.: A. H. Povah Fp. 264, J. L. Lowe & J. B. McFarlin Fp. 302; LIVINGSTON Co.: F. Hoseney 797, 863, 1049; A. H. Smith 1426; W. Patrick 31 July 1970, H. V. Smith 2 Aug. 1970; LUCE Co.: A. H. Smith 33253, 37187; N. J. Smith 648, 649, 2255; MARQUETTE Co.: W. Patrick 972; N. J. Smith 1162, 1267, 1285, 1337, 1360, 1389, 1504, 1505, 1530, 1531, 1549; N. S. Weber 2468, 2472, 2481; MENOMINEE Co.: C. O. Grassl 6829; MONTMORENCY Co.: N. J. Smith 312, 619; MUSKEGON Co.: A. H. Smith 5099, 5001; OAKLAND Co.: A. H. Smith 6750, 6769; OTSEGO Co.: N. J. Smith 2267; SCHOOLCRAFT Co.: I. Bartelli 3240, 3241, 3242, 3243; WASHTENAW Co.: F. Hoseney 905, 1180; A. H. Smith 1516; D. Swarts 8 Oct. 1926; N. S. Weber 2462, 2493, 2494, 2495, 2496, 2497.

16. *Helvella lacunosa* Fries, Systema Mycologicum 2: 15. 1822.
Type: "Not available" (Dissing, 1966).
Illustrations: Figs. 38, 39.

Apothecium 1-5 cm high, 2-4 cm broad, irregularly mitrate to convex with the sides appressed to the stipe or saddle-shaped and not compressed, seldom with an acute sinus. Margin variable in curvature, but not curving over the hymenium; edge entire or often lacerate in age. Hymenial surface pale gray to medium gray or black, rarely white; even, rugose, or mammose, the irregularities most pronounced above the stipe apex. Sterile surface of the apothecium various shades of gray to black, rarely white; glabrous; ribbed, the ribs extending from the stipe apex toward the margin, often branching, often appearing interconnected when dry, concolorous with the sterile surface or lighter; ingrown with portions of the apothecium or stipe at several points, rarely free.

Stipe 6-13 cm long, 1-3 cm thick; even or tapering toward the apex; costate, the ribs rounded and cord-like or double-edged, branching and anastomosing; dingy white to gray or black, darkest on the ribs and often paler near the base; glabrous; lacunose internally and externally at some point in development.

Fig. 38. *H. lacunosa,* ×½, N. J. Smith 2141, showing color variation.

Spores (16.5-)17.5-21(-22) × (10.5-)12-14 μ, ellipsoid, with one oil droplet, smooth or in age verrucose-rugulose. Hymenium 250-380 μ thick. Paraphyses hyaline to light brown, pigment when present in the walls; clavate to subcapitate, the clava 4-10 μ wide.

Ectal excipulum of the apothecium 50-130 μ thick; of *textura angularis* with a palisade of clavate to rounded hyphal end cells forming the outer edge; hyaline to gray, the pigment in the cell walls. Medullary excipulum 80-300(-600) μ thick; of *textura intricata,* the hyphae hyaline, 3-10(-20) μ wide. Ectal excipulum of the stipe 60-100(-400) μ thick, thinnest over the ribs, of *textura angularis* with a palisade of clavate to rounded hyphal end cells forming the outer edge, hyaline to pale grayish brown due to wall pigmentation. Medullary excipulum of *textura intricata,* the hyphae hyaline, clear, or refringent, 3-6 μ wide.

Scattered to gregarious in damp areas in Michigan; under conifers and mixed woods in wet and well drained habitats in the western United States. It fruits in the late summer and fall and is terrestrial.

In Michigan, *Helvella lacunosa* is not common. The Michigan material tends to be darker in color and more regularly saddle-shaped than the majority of material from the western United States. *H. lacunosa* is separated from *H. sulcata* and *H. palustris,* the two species most readily confused with it, by the combination of autumnal fruiting, irregularly mitrate to broadly saddle-shaped apothecium which is relatively large, and the lacunose stipe.

H. lacunosa and *H. sulcata* were described by Afzelius (1783) and Fries (1822) maintained the distinction. Post-Friesian workers have not consistently

Fig. 39. *H. lacunosa,* ×1, A. H. Smith 77156.

recognized the two taxa, and a survey of various publications shows that much confusion existed about these species. The proportions of this muddle are readily apparent when one examines the list of synonyms of *H. lacunosa* in Dissing's paper (1966).

My concept of the species is based on the information presented by Fries (1822) and supplemented by an examination of the illustrations and descriptions cited by him. In addition, I studied an excellent collection made by Atkinson (Atk. 15823, CUP) near Uppsala in company with Robert Fries. The collection was identified by Robert Fries as *H. lacunosa,* and morphologically and anatomically it is indistinguishable from what is known in this country as *H. lacunosa.* The characters of Atkinson's collection are also in agreement with the Friesian description of *H. lacunosa.*

Helvella lacunosa can almost be characterized as variable, but the species

actually varies within definite limits. In the fall of 1968, in northern Idaho, *H. lacunosa* was the most common species of Discomycete. Over 900 specimens of it were seen by a single collector in one day. It was quite variable in color, apothecial shape, and size, but the basic morphology of the stipe and the extremes of apothecial shape were relatively constant. For example, both stipe and hymenium varied from nearly white to black and all possible combinations of light and dark stipes and apothecia were observed. However, in isolated fruitings, all specimens were consistent in shape and color. No significant breaks in the spectrum of color or shape variation were observed. However, if only a few specimens representing separate points in the spectrum of variants are examined, one might believe that several taxa are represented. This may have happened in Europe and may explain, in part, why so many varieties and new species have been described in the *H. lacunosa* group.

Material examined: CANADA: NOVA SCOTIA: ANNAPOLIS Co.: K. Harrison 8790, 8828. GERMANY: R. L. Shaffer 4947. SWEDEN: UPPLAND: G. F. Atkinson 15832 (CUP). U.S.A.: CALIFORNIA: SAN MATEO Co.: Orr 53; SANTA BARBARA Co.: P. M. Rea 1338B; IDAHO: BONNER Co.: A. H. Smith 73720, 76058, 76281, 76297, 76314, 76283, 77029, 77135, 77155, 77156, 77157; N. J. Smith 1972, 1973, 1989, 1990, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2020, 2023, 2024, 2025, 2027, 2028, 2029, 2030, 2041, 2042, 2043, 2044, 2045, 2046, 2065, 2080, 2085, 2086, 2113, 2113, 2137, 2138, 2140, 2141, 2142, 2143; BOUNDARY Co.: K. Harrison 6279; IDAHO Co.: A. H. Smith 70231; KOOTENAI Co.: N. J. Smith 2081; MICHIGAN: ALGER Co.: D. Swartz 23 Aug. 1927; CHEBOYGAN Co.: A. H. Smith 66393; KEWEENAW Co.: H. & V. Bailey 201; WASHTENAW Co.: A. H. Smith 77167; NEW MEXICO: SANDOVAL Co.: K. Harrison 9 Sept. 1967, 7047; SANTA FE Co.: C. Barrows 478, 1999; WASHINGTON: PEND OREILLE Co.: A. H. Smith 70755; N. J. Smith 2115, 2116, 2117.

17. *Helvella palustris* Peck, Rep. N.Y. St. Mus. Nat. Hist. 33: 31. 1880.
Helvella philonotis Dissing, Svensk Bot. Tidskr. 60: 117. 1964 (types compared).

Type: New York: Among mosses and liverworts in swamps, Manlius, August, C. H. Peck (NYS).

Illustration: Fig. 40.

Apothecium 1-4.5 cm broad, 5-15 mm high; when young peltate to deflexed, at maturity variable in shape, often irregularly saddle-shaped with a shallow sinus and convex lobes. Margin straight to curved toward the stipe in age; edge typically entire, free when young, often ingrown with the stipe in age. Hymenial surface sooty black to gray; when young even, in age often slightly rugose. Sterile surface when young black, in age gray to black, paler than the hymenial surface; glabrous; with 3-6 ribs present occasionally on older material, the ribs radiating from the stipe apex; when young free, in age usually ingrown with the stipe or other portions of the ascocarp.

Stipe 1.5-6 cm long, 3-9 mm thick; tapering apically; costate, the ribs solid, single or occasionally double-edged; light to dark gray, often paler near the base; glabrous; solid.

Spores (15.5-)16.5-19(-21) × 11-12.5 μ, ellipsoid, with a single oil droplet, smooth. Hymenium 200-300 μ thick. Paraphyses light brown with brown walls; clavate, the clava 4-10 μ broad. Asci 8-spored, 12-14 μ broad.

Fig. 40. *H. palustris,* ×1, N. J. Smith 2390.

Ectal excipulum of the apothecium 50-90(-120) μ thick, a palisade of clavate hyphal end cells, hyaline or some cells with a continuous or irregular brown wall layer. Medullary excipulum 100-300(-500) μ thick; of *textura intricata,* the hyphae hyaline, 3-10 μ wide. Ectal excipulum of the stipe 80-250 μ thick, of *textura angularis* with a palisade of clavate hyphal end cells along the outer edge, a mixture of hyaline cells and cells with light brown walls. Medullary excipulum of *textura intricata,* the hyphae 2.5-4 μ wide, some hyaline, others with brown walls.

Scattered to gregarious in damp or wet areas, frequently under white cedar. It often fruits on twigs, moss stems, and other debris along small streams from July to October.

Dissing (1966) regarded *Helvella palustris* as a synonym of *H. lacunosa.* An examination of the type of *H. palustris* and of Peck's illustration indicate to me that *H. palustris* is distinct from *H. lacunosa* as here interpreted. The slim stipe which lacks lacunae, characteristically small saddle-shaped apothecium, and the relatively small size are distinctive. An examination of the type of *H. philonotis* indicates that it is conspecific with *H. palustris.*

Material examined: MICHIGAN: CHEBOYGAN Co.: A. H. Smith 22174, 26161; N. J. Smith 2224, 2294, 2307, 2344, 2423; CHIPPEWA Co.: N. J. Smith 2261; EMMET Co.: A. H. Smith 22089, 26251, 49835; N. J. Smith 2379, 2386, 2390; KEWEENAW Co.: J. Lowe & A. H. Povah Fp. 256; MARQUETTE Co.: N. J. Smith 1431.

Section *Elasticae* Dissing, Dansk Bot. Ark. 25: 128. 1966.
Type species: *Helvella elastica.*

Apothecium deflexed to saddle-shaped or lobed. Margin when young plane, or in most species, curving over the hymenial surface and often obscuring it; at maturity straight or variously curved. Hymenial surface pale tan to dark gray-brown, smooth or rarely rugose. Sterile surface of the apothecium pale, cream color or pale tan; glabrous or finely pubescent to villose; even. Stipe terete and even to compressed; light in color, pale buff to white; glabrous to finely pruinose. Asci pleurorhynchous.

Dissing (1966, p. 29) separated Section *Elasticae* and Section *Ephippium* on the basis of pubescence. Here color has been emphasized. As a result, some species with a pubescent sterile surface and some with a glabrous sterile surface are included in each section. There are known or postulated intermediates between the glabrous and pubescent condition in each section which, I believe, may be indicative of evolution within each group. In contrast, no intermediates in pigmentation have been observed between the sections (as I have envisioned them) thus indicating that differences in pigmentation may be more fundamental than those of pubescence in this instance.

Three species known from Michigan.

18. *Helvella elastica* Fries, Systema Mycologicum 2: 21. 1822.
Leptopodia elastica (Fr.) Boud., Bull. Soc. Mycol. France 1: 99. 1885.
Tubipeda elastica (Fr.) Falck, Mycol. Unters. Ber. 1: 377. 1923.
Type: "No type available" (Dissing, 1966).
Illustrations: Figs. 14, 41, 42.

Apothecium 0.5-4 cm high, 1-4(-6) cm broad; deflexed to saddle-shaped with a broad sinus between slightly ascending lobes, the lobes convex, sometimes overlapping and fusing at maturity. Margin flaring to curved toward the stipe; edge entire or irregularly lacerate in age, free or occasionally ingrown with the stipe or parts of the apothecium. Hymenial surface tan to pale gray-tan or dark gray-brown, even. Sterile surface of the apothecium white to pale tan, lighter than the hymenial surface; glabrous; even; when young free, in age occasionally ingrown with the stipe or parts of the apothecium.

Stipe 2-6(-11) cm long, 2-8(-12) mm thick; terete and even to compressed, tapering toward the apex; cream color to pale buff; glabrous to minutely pruinose near the apex.

Spores (18-)19.5-22.5(-24) × 11.5-13.5 μ; ellipsoid to oblong; when fresh with one large central oil droplet and 0-5 small droplets at each end, when revived in water with a single oil droplet; smooth or rarely verrucose-rugulose. Hymenium (150-)200-300 μ thick. Paraphyses hyaline to pale tan; clavate, the clava 5-11 μ broad. Asci 8-spored, 15-17 μ broad.

Ectal excipulum of the apothecium 85-200 μ thick; of *textura angularis* with an even outer edge or rarely a few projecting hyphae, at maturity the individual cells often subglobose and loosely arranged (approaching *textura globosa*); hyaline. Medullary excipulum 100-300 μ thick; of *textura intricata,*

Fig. 41. *H. elastica,* ×2, N. J. Smith 2097, young specimens.

Fig. 42. *H. elastica,* ×1, N. J. Smith 2104, mature specimens.

the hyphae hyaline, 3.5-7(-15) μ wide. Ectal excipulum of the stipe 350-400 μ thick; of *textura angularis* with scattered projecting hyphae and hyphal cells along the outer edge, hyaline. Medullary excipulum of *textura intricata*, the hyphae hyaline, 2.5-3.5 μ wide.

Solitary to gregarious on wet or well drained soil or rarely on rotting wood. In Michigan it is frequently found along clear streams under either conifers or hardwoods, and it fruits from August to frost. *Helvella elastica* is one of the more variable species in the genus in habitat specificity.

Helvella elastica is a variable species in color, stature, and habitat, but it can be distinguished from similar species by its permanently glabrous sterile surface on the apothecium, by the margin which never curves over the hymenium, and by the shallow sinus between the lobes of the apothecium. It is sufficiently different from the other species in Section *Elasticae* that the other species may eventually require recognition of a new section.

Material examined: CANADA: QUEBEC: F. L. Drayton 5339. FRANCE: R. L. Shaffer 4768, 5146. GERMANY: R. L. Shafer 5036. U.S.A.: IDAHO: BONNER Co.: N. J. Smith 2072, 2097, 2101, 2102, 2103, 2104, 2125; IDAHO Co.: A. H. Smith 10 Aug. 1962, 58607; SHOSHONE Co.: A. H. Smith 73607; VALLEY Co.: A. H. Smith 66134; MICHIGAN: CHEBOYGAN Co.: T. E. Brooks 1351; M. V. Charlton G142; R. L. Shaffer 3680; A. H. Smith 23445; N. J. Smith 2221, 2264, 2282, 2292, 2300, 2422; CHIPPEWA Co.: A. H. Smith 49993; N. J. Smith 2260; EMMET Co.: E. B. Mains 33-472; A. H. Smith 42667; N. J. Smith 2353, 2381; KEWEENAW Co.: J. L. Lowe Fl. 207, 259; A. H. Povah Fp. 764; LUCE Co.: E. B. Mains 33-536; MACKINAC Co.: N. J. Smith 2237, 236s; MARQUETTE Co.: I. Bartelli 3142, 3244, 3288; E. B. Mains 32-557; N. J. Smith 1227, 1240, 1406, 1432; 1488, 1489, 1900, 1963; N. S. Weber 2484; MONTCALM Co.: V. Potter 6791; ONTONAGON Co.: H. Peters 1208, J. F. Ammirati 3803; WASHTENAW Co.: J. F. Ammirati 2551, 2643; F. Hoseney 1403; R. L. Shaffer 3653; A. H. Smith 32-406, 77168, 77172; N. J. Smith 761, 2147, 2148, 2149, 2150; N. S. Weber 2498; NEW MEXICO: C. Barrows 2022; LOS ALAMOS Co.: K. Harrison 7379; SANDOVAL Co.: K. Harrison 7056, 7155; WASHINGTON: CLALLAM Co.: A. H. Smith 14745; PIERCE Co.: H. Imshaug 1217; A. H. Smith 29324, 40433, 47423; WYOMING: ALBANY Co.: B. B. Kanouse 5 Sept. 1925.

19. *Helvella stevensii* Peck, Bull. Torrey Bot. Club 31: 183. 1904.
Leptopodia stevensii (Peck) LeGal, Rev. Mycol. (Paris) 2: 156. 1937.
Helvella connivens Dissing & Lange, Mycologia 59: 351. 1967 (type examined).

Type: Michigan: Detroit, June 1903, R. L. Stevens (NYS).
Illustrations: Figs. 43-46.

Apothecium 1-4.5 cm high, 0.8-3.5 cm broad; compressed; involute when young to saddle-shaped to trilobate at maturity with ascending lobes forming an acute sinus. Margin when young involute and obscuring the hymenial surface, gradually expanding and unrolling, in age inclined toward the hymenial surface to flaring; edge entire or in age irregularly lacerate, typically free of the stipe. Hymenial surface tan to buff, "Light Buff" to "Light Ochraceous Buff"; even. Sterile surface of the apothecium light cream color or pale buff. finely granulose to pubescent; even; when young free, rarely ingrown with the stipe at maturity.

Stipe 1-6(-13) cm long, 2-6(-12) mm thick; terete to compressed, even,

tapering toward the apex; cream color to whitish apically to ochraceous-tan basally; sparsely granulose to pubescent.

Spores 17.5-20 × 11-13.5 μ; ellipsoid to oblong; when fresh with one central oil droplet and occasionally 1-2 smaller droplets at each end, when revived in water with a single droplet; smooth or rarely verrucose-rugulose. Hymenium 220-320 μ thick. Paraphyses hyaline; clavate, the clava 4-8(-10) μ broad. Asci 8-spored, 14-16 μ broad.

Ectal excipulum of the apothecium 90-150 μ thick, of *textura angularis* with numerous hyphae and hyphal fascicles projecting along the outer edge, hyaline. Medullary excipulum 70-160 μ thick; of *textura intricata,* the hyphae 3.5-17.5 μ wide. Ectal excipulum of the stipe (87-)175-300 μ thick, of *textura angularis* with projecting hyphae or hyphal fascicles along the outer edge, hyaline. Medullary excipulum of *textura intricata,* the hyphae 3.5-7 μ broad, hyaline.

Fig. 43. *H. stevensii,* ×1, N. J. Smith 990, young.

Fig. 44. *H. stevensii,* ×1, N. J. Smith 990, mature.

Scattered to gregarious on sandy soil under hardwoods. It fruits in June and July and is often found along paths and dirt roads.

Helvella stevensii is characterized by a finely granulose to pubescent sterile surface on the apothecium, involute margin when young, pale colors, and late spring to early summer time of fruiting.

A similar species, *Helvella connivens,* was described from Michigan by Dissing and Lange (1967). An examination of the type of *H. connivens* (Emmet Co., Michigan, 21 July 1947, A. H. Smith 25872, MICH) revealed little quantitative or qualitative difference between it and *H. stevensii.* In *H. stevensii,* the margin of the apothecium is involute and the sterile surface densely pubescent (Dissing & Lange, 1967). In fresh and dried collections of *H. stevensii* such specimens were present, but many others had a flaring margin and the proportion of mature spores was considerably higher than in specimens with involute margins. The type collection of *H. connivens* contains a majority of nearly or completely expanded apothecia and a few specimens with involute margins which were superficially identical with *H. stevensii.* As a result of these observations, I hypothesized that the two species represented different stages of growth in a single species. An effort was made during the 1969 collecting season to locate young specimens of *H. stevensii* and observe their growth over a period of time. Such a fruiting was found at the University of Michigan Biological Station (N. J. Smith 2172). Initially, the ascocarps were partially or entirely buried in the soil and were less than two centimeters high. During the ensuing two or three weeks, the apothecia were pushed through the soil by the elongation of the stipe. At the same time, the apothecia expanded and passed from an involute phase to saddle-shaped with progressively less curvature of the margin. The vesture on the sterile surface of the apothecium became less and less conspicuous as the apothecia enlarged. By the end of the study, what began as *H. stevensii* had become *H. connivens.* Thus, *H. connivens* is considered to be a synonym of *H. stevensii* here.

Material examined: MICHIGAN: CHEBOYGAN Co.: N. Beach 28 June 1957; T. E. Brooks 1258; A. H. Smith 25820, 75432; N. J. Smith 47, 990, 996, 997, 1004, 1014, 2172, 2197, 2211; H. Thiers 2 July 1964; EMMET Co.: R. L. Shaffer 3977; A. H. Smith 25872, 36699, 39263; N. J. Smith 95, 267, 2209; H. Thiers 3467, 3689; GRATIOT Co.: V. Potter 4903, 4906, 5108, 5109, 5308, 5417, 9690, 9801; LIVINGSTON Co.: F. Hoseney 443, 799, 854; MONTMORENCY Co.: N. J. Smith 420; WASHTENAW Co.: Mrs. Burt; F. Hoseney 833; C. H. Kauffman 17; E. B. Mains 26 June 1945, 9515; A. H. Smith 6416, 15149, 20478, 62479; N. J. Smith 994; WAYNE Co. (probably): R. L. Stevens May 1903 (NYS), 1906.

20. *Helvella albella* Quélet, Assoc. Franc. Avancem. Sci. Conf. (Bordeaux, 1895) 24: 621. 1896.

Leptopodia albella (Quél.) Boud., Icones Mycol. 4: 123. 1905-1910.

Type: "No type available" (Dissing, 1966).

Illustration: Fig. 47.

Apothecia 1-2.5 cm high, 9-22 mm broad; when young sub-plane to saddle-shaped with involute margins, at maturity saddle-shaped to trilobate with ascending lobes. Margin when young curving over the hymenial surface and often obscuring it, in age expanding and flaring; edge entire or irregularly

Fig. 45. *H. stevensii,* slightly larger than natural size, N. J. Smith 2172, young (photo by the author).

Fig. 46. *H. stevensii,* slightly larger than natural size, N. J. Smith 2172, mature (photo by the author).

lacerate in age. Hymenial surface gray-brown, "Drab" to "Buffy Brown" or "Hair Brown"; even. Sterile surface of the apothecium paler than the hymenial surface, cream color to nearly white; when young villose to pruinose, in age the vesture less pronounced to nearly glabrous; even; free of the stipe.

Stipe 1.7-5 cm long, 2-6 mm thick; terete, even, tapering toward the apex; glabrous to finely pruinose; whitish.

Spores 20-22(-23.5) X (12.5-)13.5-14.5 μ; oblong to ellipsoid; when fresh with one large central oil droplet and 0-4 small droplets at each end, when revived in water with a single large droplet; smooth. Hymenium 260-320 μ thick. Paraphyses hyaline to yellowish brown due to intracellular pigment; clavate, the clava 6-18 μ broad. Asci 8-spored, 18-20 μ broad.

Ectal excipulum of the apothecium 80-150 μ thick, of *textura angularis* with scattered hyphae and groups of hyphae projecting along the outer edge, hyaline. Medullary excipulum 70-200 μ thick; of *textura intricata,* the hyphae hyaline, 3.5-11 μ wide. Ectal excipulum of the stipe 200-260 μ thick, of *textura angularis* with numerous hyphae projecting along the outer edge, hyaline. Medullary excipulum of *textura intricata,* the hyphae hyaline, 2-6.5 μ wide.

Scattered to gregarious on damp soil under white cedar. It fruits in September and October and has been found only on very wet soil along streams under white cedar.

Fig. 47. *H. albella,* ×1, N. J. Smith 2340.

Helvella albella can be recognized by the combination of fruiting time, terete stipe, involute margin on the apothecium, and gray-brown colors of the hymenium.

As with *Helvella stevensii, H. albella* looks quite different when young and when mature, but the various stages can be connected by material of intermediate ages. Occasionally apothecia of *H. albella* are found which are cupulate when young, but they were growing with normal specimens and did not differ from them in microscopic characters. A series of stages in the reduction in prominence of the vesture can be traced from very young to old specimens. In fact, Dissing (1966) considered *H. albella* to be glabrous on the sterile surface of the apothecium although Quélet did not describe the species as glabrous.

Material examined: COLORADO: SAN MIGUEL Co.: A. H. Smith 52422; MICHIGAN: CHEBOYGAN Co.: N. J. Smith 2340, 2348, 2349, 2350, 2419, 2420, 2421; EMMET Co.: N. J. Smith 2415, 2377.

Section *Helvella*
Section *Crispae* Dissing, Dansk Bot. Ark. 25: 85. 1966.
Type species: *Helvella crispa.*

Apothecium saddle-shaped to lobed. Margin rolled over the hymenium when young, in age straight or flaring; edge entire to lacerate. Hymenial surface buff to umber brown, even to rugose over the stipe apex. Sterile surface of the apothecium roughened, furfuraceous to pruinose; even. Stipe costate, glabrous, pale buff to cream color. Asci pleurorhynchous.

One species known from Michigan.

The name of this section must be *Helvella* since, according to the *International Code of Botanical Nomenclature* Art. 22 (Stafleu *et al.,* 1972), subgenera or sections of a genus which include the type species of the genus take their name from the genus.

21. *Helvella crispa* Fries, Systema Mycologicum 2: 14. 1822.
Type: Tab. 86, Fig. 7 in Micheli, Nov. Pl. Gen. 1729 (Dissing, 1966).
Illustration: Fig. 48.

Apothecium 1-4 cm high, 0.7-5 cm broad; saddle-shaped to lobed with a broad sinus. Margin when young rolled up and obscuring the hymenial surface, gradually expanding and unrolling; in age flaring; edge entire to irregularly lacerate. Hymenial surface pale cream color, "Ivory Yellow" to "Light Buff"; in age wrinkled near the center, even at the margin. Sterile surface of the apothecium concolorous with the hymenial surface to slightly darker, "Warm Buff"; pruinose; with short ribs near the stipe apex, otherwise even; typically free.

Stipe 2.5-10 cm long, 1-3.5 cm thick; expanding above the base and tapering towards the apex; costate, the ribs when young rounded, often becoming sharper in age, branching and anastomosing; nearly concolorous with the hymenial surface to "Pinkish Buff"; glabrous to finely pruinose; lacunose superficially and internally, the lacunae often enlarging with age.

Spores (14-)17-21(-24) × 10-13(-14) μ; ellipsoid; when fresh with one

large central oil droplet and 0-4 small droplets at each end, when revived in water with a single oil droplet; smooth or rarely verrucose-rugulose. Hymenium 230-350 μ thick. Paraphyses hyaline; narrowly clavate, the clava 5-9 μ wide. Asci 8-spored, 16-17.5 μ wide.

Ectal excipulum of the apothecium 70-175(-210) μ thick, of *textura angularis* with individual hyphae or fascicles of hyphae projecting along the outer edge, hyaline. Medullary excipulum 140-320 μ thick; of *textura intricata,* the hyphae hyaline, 3-10 μ wide. Ectal excipulum of the stipe 70-340 μ thick, of *textura angularis* with or without scattered hyphae or fascicles of hyphae projecting along the outer edge, hyaline. Medullary excipulum of *textura intricata;* the hyphae hyaline, 2.5-3.5 μ wide.

Solitary to scattered or gregarious on the ground or rotting woody debris. It frequently is found in coniferous areas, but it is also known from hardwoods, and fruits in relatively wet areas as under white cedar or in well drained areas as along roads and paths. It usually fruits from August to frost.

Helvella crispa is a distinctive species in the Michigan flora. No other species of *Helvella* in the state has the combinations of a buff to cream color apothecium with an inrolled margin when young, a pruinose sterile surface on the apothecium, and a buff to pinkish buff costate stipe.

Material examined: CANADA: ONTARIO: E. Bartholomew 3329, H. A. Kelly 354. ENGLAND: SURREY: ex Herb. Hort. Bot. Reg. Kew, 7 Oct. 1951. FRANCE: OISE: R. L. Shaffer 5207. SWEDEN: UPPLAND: R. A. Nannfeldt 15 Sept. 1969. U.S.A.: FLORIDA: ALACHUA Co.: W. Isaacs 2432; IDAHO: BONNER Co.: K. Harrison

Fig. 48. *H. crispa,* ×1. N. J. Smith 1621.

6355; IDAHO Co.: A. H. Smith 46550; MICHIGAN: ALGER Co.: E. B. Mains 32-713; BARRY Co.: S. J. Mazzer 4236; CHEBOYGAN Co.: P. Harding 324; A. H. Smith 22350, 50082; N. J. Smith 2298, 2299, 2341, 2342, 2343, 2347, 2424, 2426; EMMET Co.: C. H. Kauffman 310; A. H. Smith 42751, 42938, 43657; N. J. Smith 2382, 2413; KEWEENAW Co.: H. & V. Bailey 196; LIVINGSTON Co.: R. Homola 1093; F. Hoseney 1372; A. H. Smith 78467; LUCE Co.: N. J. Smith 2368; MACKINAC Co.: N. J. Smith 2304, 2458, 2433; MARQUETTE Co.: I. Bartelli 3144, 3245; N. J. Smith 1357, 1507, 1621; N. S. Weber 2471; MIDLAND Co.: N. J. Smith 812; ONTONAGON Co.: H. Peters 1209; ROSCOMMON Co.: E. B. Mains 6313; WASHTENAW Co.: J. F. Ammirati 2550; G. B. Cummins 29 Sept. 1929; F. Hoseney 1097, 1107; C. Nimke 5 Aug. 1970; A. H. Smith 6915, 77169, 78381; N. J. Smith 2146; WAYNE Co.: O. E. Fischer 27 Aug. 1905; NEW MEXICO: C. Barrows 1607, 3039; LOS ALAMOS Co.: K. Harrison 7381; SANDOVAL Co.: K. Harrison 7048, 7050, 7052; SANTA FE Co.: K. Harrison 6932; OHIO: GREENE Co.: W. B. & V. G. Cooke 37895; WARREN Co.: W. B. & V. G. Cooke 36321; UTAH: K. H. McKnight F1554; WASHINGTON: CLALLAM Co.: A. H. Smith 17192.

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ANALYSIS OF A TERRESTRIAL LICHEN POPULATION AT GRASS LAKE, MISSAUKEE COUNTY, MICHIGAN

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Northern Lower Michigan supports a rich and diverse lichen flora, but few population studies of terrestrial lichens have been made in the area. Therefore, we investigated the distribution of terrestrial species, their cover abundance, and species composition in three lowland vegetational types.

METHODS

The area selected was a low-lying field west of Grass Lake in northern Missaukee County, Norwich Township (T-24-N, R-5-W), Michigan. The field is bordered on the east by Grass Lake, on the north and west by shallow standing water which is probably not present during dry periods, and on the south by upland woody vegetation. The area is irregular in outline and is 50 X 55 meters in its greatest dimensions. The soil is quite sandy and has a pH of 4.5 to 6.0. A 55-meter baseline was established on the eastern border of the area in a north-south orientation, and six transects of varying lengths were positioned at 10-meter intervals along the baseline. Figure 1 shows the orientation of the baseline and the transect lines with respect to the vegetational types within the study area.

The transect lines were marked at one-meter intervals, and an area 25 cm on either side of the transect line for a distance of one meter constituted one quadrat. The number of colonies and cover abundance rating for each species in each quadrat were recorded. In addition, those colonies which were intersected by the transect line were measured and given a colony size rating. The scales used for rating cover abundance and colony size were similar to those discussed by Benninghoff (1966), with some modification, and are as follows:

Cover Abundance Scale

5 Covering more than 3/4 of the quadrat
4 Covering 1/2-3/4 of the quadrat
3 Covering 1/4-1/2 of the quadrat
2 Covering 1/20-1/4 of the quadrat
1 Covering less than 1/20 of the quadrat

Colony Size Scale

5 Colony over 25 cm in diameter
4 Colony 16-24 cm in diameter
3 Colony 9-15 cm in diameter
2 Colony 5-8 cm in diameter
1 Colony 1-4 cm in diameter

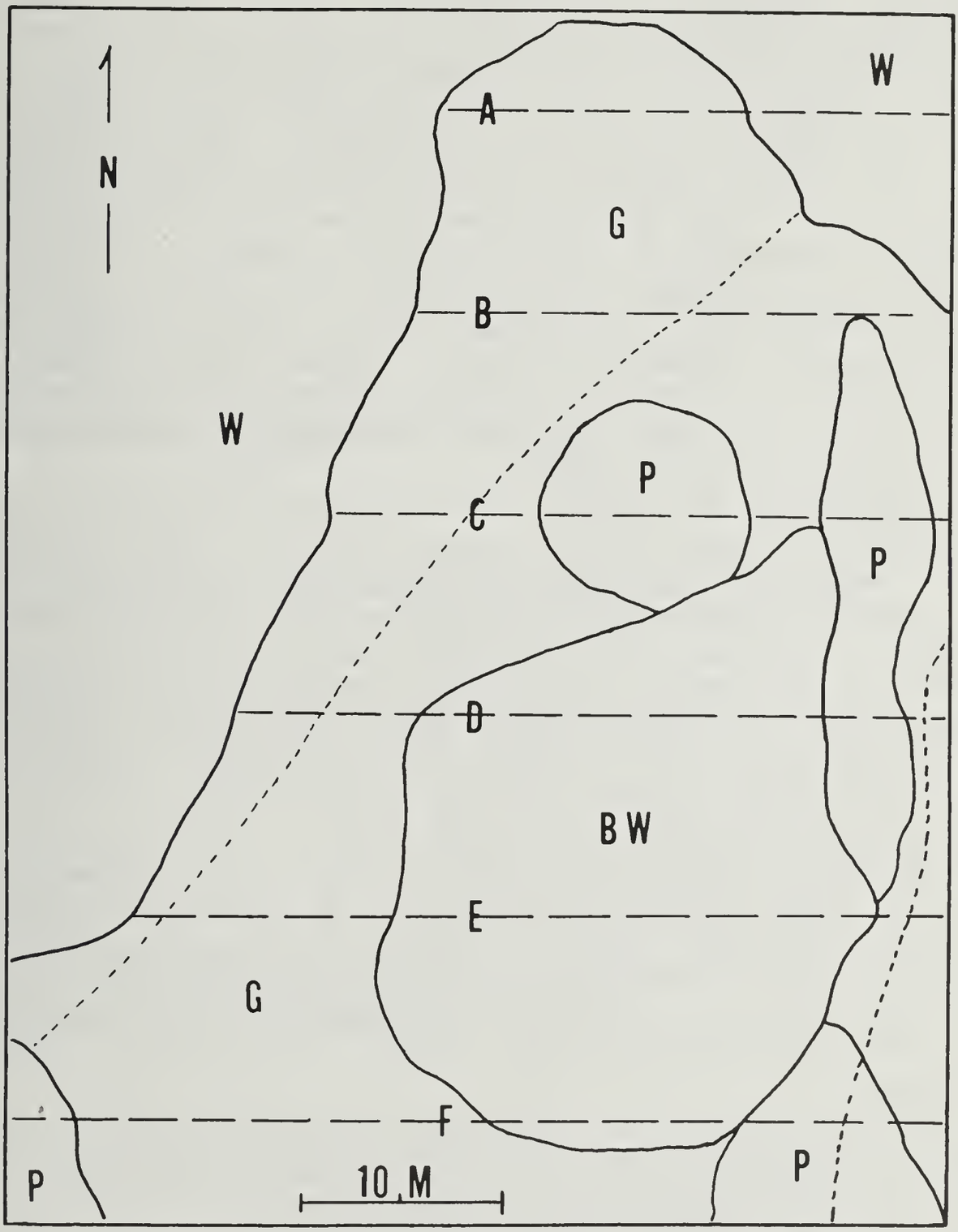

Fig. 1. Position of transect lines in the study area in relation to vegetational types. A-F, transect lines; BW, blueberry-willow area; P, cherry-poplar area; G, grass area; W, standing water. The right margin of the figure respresents the position of the baseline. Drainage ditches are indicated by dashed lines.

RESULTS

Vegetational Composition of the Area. Three distinct areas, differing in vascular plant composition, were present in the study area (Fig. 1). The grass area consisted of bog-reed grass (*Calamagrostis inexpansa* A. Gray), wild strawberry (*Fragaria* sp.), and devils paintbrush (*Hieracium aurantiacum* L.). The blueberry-willow area consisted of *Vaccinium* sp., *Salix* sp. 2-4 feet in height, and sweetfern (*Comptonia peregrina* (L.) Coulter). The cherry-poplar area consisted of black cherry (*Prunus serotina* Ehrh.), trembling aspen (*Populus tremuloides* Michx.) 6-8 feet in height, and *Salix* sp.

Eight terrestrial lichen species were found in the study area. These were *Cladonia cristatella* Tuck., *C. verticillata* (Hoffm.) Schaer., *C. chlorophaea* (Flk.) Spreng., *C. pyxidata* (L.) Hoffm., *C. capitata* (Michx.) Spreng., *C. fimbriata* (L.) Fr., *C. rangiferina* (L.) Wigg., and *Peltigera polydactyla* (Neck.) Hoffm. No effort was made to distinguish among the four "chemical species" of *C. chlorophaea* (Thomson, 1967).

Species Distribution. As expected, lichen populations reached their highest development in the grass area. The numbers of colonies, numbers of species, cover abundance, and colony size were lowest in the blueberry-willow area and highest in the grass area. *C. cristatella* was found in all three areas. *C. verticillata, C. pyxidata,* and *C. chlorophaea* occurred primarily in the grass area but were also present in the transition zone between the cherry-poplar and grass areas. The remaining *Cladonia* species were found only in the grass area. *Peltigera polydactyla* was restricted to low-lying damp locations in the grass area, which agrees with the observation of Alvin (1960).

Cover Abundance and Species Composition. As shown in Tables 1 and 2, *C. cristatella* was the dominant lichen species in terms of both distribution and number of colonies, occurring in 40 percent of all quadrats and representing 54 percent of all lichen colonies. It was the only species represented by colony size ratings of greater than 3 (Table 3) and cover abundance ratings of greater than 3 (Table 4). Examination of Tables 1-4 indicates a relationship among distribution, frequency, cover abundance, and colony size within a given species.

Looman (1964) and others (see Hale, 1967) have found that terrestrial lichen communities are transitory and tend to be limited by the density of the covering vegetation. Our observations also show an inverse relationship between development of the lichen community and the density of the covering vegetation.

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TABLE 1. Species Percent Occurrence (Frequency) by Number of Quadrats*

Species	Transect A	B	C	D	E	F	All Transects
C. cristatella	58	89	31	49	75	22	40
C. verticillata	48	89	15	20	31	13	25
C. chlorophaea	32	68	5	9	16	3	13
C. pyxidata	27	58	8	0	16	7	13
C. capitata	42	29	5	0	8	0	9
P. polydactyla	0	14	5	4	0	0	2
C. rangiferina	0	5	0	0	0	0	1
C. fimbriata	5	4	0	0	0	0	1
Total Quadrats in Transect	24	27	29	33	45	48	206

*$\frac{\text{Number of quadrats containing indicated species}}{\text{Total quadrats}} \times 100$

TABLE 2. Species Percent Distribution by Number of Colonies in Transects*

Species	Transect A	B	C	D	E	F	All Transects
C. cristatella	54	42	57	73	57	62	54
C. verticillata	22	22	22	17	23	21	22
C. chlorophaea	10	11	6	7	8	4	8
C. pyxidata	8	13	8	0	4	13	7
C. capitata	8	9	6	0	4	0	6
P. polydactyla	0	2	3	1	0	0	2
C. rangiferina	0	1	0	2	1	0	1
C. fimbriata	1	1	0	0	0	0	1

*$\frac{\text{Number of colonies of indicated species in transect}}{\text{Total colonies of all species in transect}} \times 100$

TABLE 3. Size Ratings of Colonies in All Transects*

Species	Total Colonies with Size Rating of: 1	2	3	4	5
C. cristatella	3	68	15	7	2
C. verticillata	–	39	10	–	–
C. chlorophaea	1	29	–	–	–
C. pyxidata	1	26	–	–	–
C. capitata	6	12	1	–	–
C. fimbriata	–	2	–	–	–
C. rangiferina	2	–	–	–	–
P. polydactyla	1	1	3	1	–

*Total number of colonies with indicated rating in all transects which were intersected by the transect line.

TABLE 4. Cover Abundance of Species by Transects*

Species	Transect	Percent of Quadrats with Rating of 1	2	3	4	5
C. cristatella	A	12	25	8	–	–
	B	30	37	–	4	–
	C	10	7	3	3	–
	D	9	15	9	–	3
	E	20	18	11	2	4
	F	1	13	2	–	2
C. verticillata	A	12	21	4	–	–
	B	26	37	–	–	–
	C	3	10	–	–	–
	D	12	3	–	–	–
	E	7	20	–	–	–
	F	4	7	–	–	–
C. chlorophaea	A	12	12	–	–	–
	B	45	7	–	–	–
	C	3	–	–	–	–
	D	3	3	–	–	–
	E	13	–	–	–	–
	F	2	–	–	–	–
C. pyxidata	A	8	12	–	–	–
	B	15	15	–	–	–
	C	7	–	–	–	–
	E	11	–	–	–	–
	F	2	–	–	–	–
C. capitata	A	21	12	–	–	–
	B	19	7	–	–	–
	C	3	–	–	–	–
	E	2	–	–	–	–
P. polydactyla	B	4	11	–	–	–
	C	–	3	–	–	–
	D	–	3	–	–	–
C. rangiferina	B	4	–	–	–	–
	D	6	–	–	–	–
	E	4	–	–	–	–
C. fimbriata	A	4	–	–	–	–
	B	4	–	–	–	–

*$\frac{\text{Number of quadrats in transect with indicated rating}}{\text{Total quadrats in transect}} \times 100$

Nature education feature --

MNEMONICS FOR LEARNING ANGIOSPERM ORDERS

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Many of us are seriously "bugged" by a situation in which we are aware of prolonged, chronic ignorance of something we would very much like to know well. Maybe *you* know all the angiosperm orders and families already. If you do, there are probably few professional botanists who can offer you serious competition. Maybe, indeed, you never wanted to know the angiosperm orders and families. But for an earnest student of flowering plant evolution, it goes without saying that a goodly number of these must be learned. Of course, familiarity with typical floral anatomy of a relatively limited number of temperate plant families has its place–every little bit helps, after all–and this represents the outer limits of knowledge of even many Ph.D's in botany. Still, a solid and comprehensive view of flowering plant systematics is scarcely possible without going into the structure and other peculiarities of the many families, especially the probably primitive ones, which provide the underpinnings of evolutionary theory for the higher vascular plants.

The beginner in a project to learn something of the sweep of angiosperm evolution is faced with a truly prodigious and confusing diversity of floral types and family names. Fitting the families into orders is work for specialists and is an ongoing process of realignment, but many of the broad outlines are drawn. The geranium family, Geraniaceae, clearly belongs in the Geraniales, but several other families of this order are less easily remembered and perhaps less easily visualized. To base one's idea of Geraniales on Geraniaceae alone, or

Sergeant BerCer Ran Many Lardy Nymphs

on *Geranium,* is unquestionably better than having no ideas at all about this group, but it is clearly an inadequate approach to an understanding of the order Geraniales. Yet there are so many families! The problem is compounded for the denizens of some area, say the central United States and Canada, where many of the critical families have no familiar native representatives and few or no cultivated ones.

Thus it is that a vehicle to learn the names of unfamiliar families and to tie them into known orders can be a useful tool for a beginner, a first step to help him learn more about the order and to remember it as a distinct entity.

Let's take the Ranales, or Ranunculales. Here we have somewhat primitive families characterized partly by having numerous non-coalescent carpels, but segregated in most systems from other primitive orders such as Guttiferales which have coalescent carpels. Some of the families included in Ranales are exotic and have unfamiliar names. Although the families are few, keeping them in mind is much easier if you apply some mnemonic guide to their retention. If you are willing to sacrifice absolute fidelity of letter and modify a leading vowel here or there, the following phrase will serve to keep in mind the families of the order Ranales:

"Sargeant BerCer Ran Many Lardy Nymphs"

(Sargeant	for	Sargentodoxaceae
BerCer	for	Berberidaceae and Ceratophyllaceae
Ran	for	Ranunculaceae
Many	for	Menispermaceae
Lardy	for	Lardizabalaceae
Nymphs	for	Nymphaeaceae)

For this and the following mnemonic phrases the system of Engler's Syllabus (Melchior, 1964) is adopted. This of course is no reflection on the Cronquist-Takhtajan systematics (Cronquist, 1968; Takhtajan, 1959)—merely an indication that a few selected Englerian orders lend themselves to some of the frankly extravagant mnemonic phrases presented in this article.

When an order includes too few families to make a workable mnemonic series, two or more orders can be grouped together. Thus the resources of three Englerian orders, Sarraceniales, Papaverales, and Batales, all somewhat primitive, can be pooled to yield the following coherent series:

Resolute	Resedaceae
Saracen	Sarraceniaceae
Captain	Capparaceae
Took	Tovariaceae
Morning	Moringaceae
Nap,	Nepenthaceae
Drove	Droseraceae
Papal	Papaveraceae
Crusaders	Cruciferae
Back.	Bataceae

However, a composite group such as this one has a built-in error factor: the user may be led to think that the families are related at the order level. Furthermore, the exigencies of the mnemonic narrative do not permit—at least not in this case—the separation, within the series, of the families of Sarraceniales from those of Papaverales: here they are all mixed happily together.

The Guttiferales, another relatively primitive series, lends itself, again by judicious abuse of a vowel or consonant when necessary, to the following somewhat incredible scenario:

Your	Eucryphiaceae
Marquis,	Marcgraviaceae
Dining	Dioncophyllaceae
On	Ochnaceae
Dipped	Dipterocarpaceae
Medusa	Medusagynaceae
Gut,	Guttiferae
Answered	Ancistrocladaceae
Crossly,	Crossosomataceae
"Action,	Actinidiaceae
Peons,	Paeoniaceae
Carry	Caryocaraceae
Queen	Quiinaceae
Dillenia	Dilleniaceae
To	Theaceae
Strassbourg!"	Strasburgeriaceae

Your Marquis, Dining on Dipped Medusa Gut . . .

Naturally, there are pitfalls. A modicum of homework is necessary to avoid being led astray by a remembered or half-remembered mnemonic phrase. The user must bear in mind that "dipped" in the above series refers to nothing but the Dipterocarp family; neither the Dipsacaceae, nor Diapensiaceae, nor Dipentodontaceae will do. Note also that Medusagynaceae may be confounded with Medusandraceae, a family placed in its own order, Medusandrales.

It should be emphasized again that the mnemonic device is most useful to beginners. And yet its service is probably most efficiently rendered when certain family names have been fleshed out with some elementary notion of the plants contained in those families. Then, when there is a question of the evolutionary peers of, say, the Guttiferae, "But of course!" you say, "The peonies, the dipterocarps!" There are some 340 families of angiosperms. Losing a few of them in the bypaths and recesses of the human memory can happen to almost anybody; hence the value of the mnemonic phrase. The advanced scholar who knows both plants and families is likely to have no need of mnemonic devices. For him the grand strategies are apparent. Families fit together, interlock, and form a consistent whole—or at least in some cases they do.

It is evident that the user of mnemonic series such as these must be willing at least some of the time to settle for the initial sound of a letter or name. But this may be just enough to permit him to recall the name itself. This assumption has been made in working out the Geraniales (below) where Geraniaceae are represented by "jeer" and Zygophyllaceae by "zone."

Tropical	Tropaeolaceae
Limnologists	Limnanthaceae
Literally	Linaceae
Jeer	Geraniaceae
Erroneous	Erythroxylaceae
Euphotic	Euphorbiaceae
Zone	Zygophyllaceae
Oxygen	Oxalidaceae
Data.	Daphniphyllaceae.

Developing almost any kind of narrative phrase in English is difficult if access to the usual articles "the" and "a" is denied. This is very apparent in conceiving a mnemonic phrase to represent the lengthy series Rosales, which includes various families restricted to the tropics and other families known only from Australia or adjacent areas. Rather than work out this lengthy series *in toto,* one may prefer to exclude, for example, families not known from the Great Lakes area. In this way the Rosales can be reduced to six of the most significant and best-known members:

Legion	Leguminosae
Platoons	Platanaceae
Crave	Crassulaceae
Roast	Rosaceae
Ham	Hamamelidaceae
(and)	
Sack.	Saxifragaceae.

The Piperales and Aristolochiales check out together, as follows:

Raffish	Rafflesiaceae
Hyde Park	Hydnoraceae
Aristocrats	Aristolochiaceae
Lack	Lactoridaceae
Clean	Chloranthaceae
Sewer	Saururaceae
Pipes.	Piperaceae.

And so it goes. Any reader sufficiently bemused by this method may want to work out some of the other orders himself. Or he may feel inspired to overhaul the schemes proposed, perhaps in line with the Cronquist system, perhaps with a view to purge from higher education the depravities of Sergeant BerCer or our ill-tempered gourmet, front man for the Guttiferales, or at least to produce better mnemonic phrases. Melchior divides up the angiosperms into 62 orders, Cronquist into 74, so the field is wide open. Besides, the method works as well in groups other than angiosperms, and for units other than families in orders. If you have a block on your local genera of Labiatae, for example, or on the orders of the brown algae, try mnemonics!

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FOUR INTERESTING MOSS RECORDS FROM SOUTHWESTERN ONTARIO

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Field studies of the bryophytes of Elgin and Middlesex counties in southwestern Ontario have produced the following interesting moss records. Specimens are in the collection of W. G. Stewart or in the herbaria indicated. We thank Dr. Howard Crum for identifications and advice.

Trematodon longicollis Michx. Elgin Co., Dunwich Twp.: In depression of roadside ditch in sandy loam, W. G. Stewart, Oct. 19, 1971, *1100* (UWO, MICH, CANM); F. S. Cook and W. G. Stewart, Dec. 12, 1971, *964* (UWO). A southeastern species occurring from New Jersey to Missouri, south to Florida and Texas, it is here at the northern limit of its range. It has also been reported from Vermont. This is apparently the first record of its appearance in Canada.

Grimmia plagiopodia Hedw. Elgin Co., Yarmouth Twp.: On calcareous stone blocks of old railway bridge abutment, W. G. Stewart, June 11, 1969, *602* (MICH) det. Crum, *706* (CANM); on old concrete of roadbridge over Catfish Creek, W. G. Stewart, June 18, 1971, *1050* (MICH); Southwold Twp.: Solitary colony on east side of old concrete culvert, built 1914, W. G. Stewart, June 8, 1971, *1038* (MICH); Bayham Twp.: On old concrete of railway culvert, dated 1911, W. G. Stewart, Aug. 7, 1971, *1085* (MICH). Crum (1970) has recently reported this *Grimmia* from Michigan and gives its range as Alaska to California and New Mexico, and local in the east from Ontario to North Dakota south to Maryland, Ohio, and Wisconsin. The above seem to constitute the only Ontario records.

Grimmia pulvinata (Hedw.) Sm. ex Sm. and Sowerby. Elgin Co., Bayham Twp.: On old concrete culvert under railway embankment, W. G. Stewart, July 11, 1970, *877* (MICH) det. Crum. Another western *Grimmia* found from British Columbia and Alberta south to Arizona (Jones, 1933). This species also seems to be new to Ontario.

Cirriphyllum illecebrum (Hedw.) L. Koch. Middlesex County, City of London: On clay soil among sparse grasses in field, F. S. Cook, March 26, 1971, *773* (UWO, MICH) det. Crum; London Twp.: On clay soil among grasses in clearing in pine plantation, F. S. Cook, April 4, 1971, *776* (UWO, CANM, TRTC). This is another southern moss at the northern limit of its range here. Apparently the only other Canadian record is one of doubtful locality collected by Drummond. According to Grout (1928) the specimen is

in Macoun's collection (now at CANM) as from "Upper Canada"; Macoun believed it may have come from Niagara Falls. The species ranges from Vermont, Illinois, and Missouri south to Florida and Louisiana.

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Crum, Howard. 1970. Mosses new to the flora of Michigan. Mich. Bot. 9: 139-141.

Grout, A. J. 1928. Moss Flora of North America North of Mexico, Vol. III, Part I, pp. 11-62. Newfane, Vt.

Jones, G. N. 1933. Grimmiaceae *in* Moss Flora of North America North of Mexico (A. J. Grout, ed.). Vol. II, Part I, pp. 1-62. Newfane, Vt.

Review

MICHIGAN FLORA Part I Gymnosperms and Monocots. By Edward G. Voss. Cranbrook Institute of Science (Bull. 55) & University of Michigan Herbarium, 1972. xviii + 488 pp., 9 col. pl. $7.50.

The right name for a plant, in one's mind, is generally the name by which one first learned it. Subsequent corrections, for whatever cause, are likely to be thought of as "that name they changed it to." I have no trouble saying *Conyza canadensis* instead of *Erigeron canadensis,* because I instigated the change myself, but I have to stop and remind myself about *Sequoiadendron giganteum* (not *Sequoia gigantea*) and *Pseudotsuga menziesii* (not *P. taxifolia*). An earlier generation had equal difficulty getting accustomed to *P. taxifolia* instead of *P. mucronata* as they had learned it.

People who learn botanical names at all usually learn them from the state or regional floras. Standard lists prepared by various governmental agencies for use by their workers are also taken mainly from the floras. Monographic and other revisionary studies are thus filtered through the floras before reaching the botanical public. As the late Professor Fernald at least once commented, this is just as well; there is a lot of tripe, as well as red meat, in the professional literature.

Writers of regional floras have usually considered it their duty (or at least their prerogative) to review and reconsider the status of all taxa included in the flora, whether they have been treated in recent monographs or not. Writers of state floras, on the other hand, have usually taken a more modest view of their function, hestitating to depart from traditional interpretations without the backing of published revisionary work. Any broader reconsideration would require study of many taxa far beyond the borders of the state, and would require herbarium and library resources not readily available to many writers of state floras.

Dr. Voss does have a major herbarium and botanical library at his disposal, but he has chosen to follow the traditional approach for state floras, giving the best distillation

he can of current opinion for the taxa included. For better or for worse, he has resisted the temptation to strike out on his own in any major reinterpretation, although the temptation was evidently very strong to do so in *Carex*. "The traditional species concepts in *Carex* have, for the most part, been followed in the present treatment. . . . This [the Ovales] is a notoriously difficult group, and there is a strong temptation to recognize fewer species. The species as recognized by Mackenzie, Fernald, and Hermann are mostly maintained here, but with the realization that some individuals will not run satisfactorily in the key." It would have been interesting to see what he might have done in this and other groups had he not felt constrained to follow traditional interpretations, but one cannot fault him for the choice he has made. I have frequently been annoyed by reviews that chastised an author for not writing the book the reviewer wanted to see, instead of the book the author wanted to write.

On an early page Dr. Voss states "A major purpose of the present Flora is to facilitate *identification* of the plants of Michigan. . . . The second major purpose of this Flora is to provide condensed information on the distribution and habitats of the plants of the state. . . . This work may therefore be thought of as an annotated checklist, with keys and distribution maps, together with some illustrations."

Dr. Voss has done very well the things he set out to do. The keys read well, and in the groups I know something about I think they will work. Nearly half of the species are illustrated with line drawings; these are attractively presented and apparently accurate. The dot maps show both the distribution and probable abundance of all species within the state at a glance. The commentary on species, genera, and families is interesting and informative. There must be some mistakes, but I have not found them. Those who know the author's attention to detail and devotion to the flora will not expect to find many. The typography of the book is well adapted to its function, contributing its part to a handsome volume.

A certain ambivalence regarding the broad-scale classification and nomenclature of the seed plants did catch my attention. In the discussion the gymnosperms are considered to constitute a division Pinophyta, but in the formal presentation they are called Gymnospermae, without indication of taxonomic rank. The monocots are accepted as a class Liliopsida of the division Magnoliophyta, but the sequence of families within the class is Englerian. The Engler system is stated to be "as obsolete for our times as the Linnaean system was a century or so ago," and then defended as being "rather like an alphabet." One is reminded of the driver who approached a Y in the highway, and died of indecision. Yet these matters will be insignificant to most users of the flora, and no more than a minor annoyance to the remainder.

In sum, Dr. Voss has done an excellent job, within the confines of the traditional functions of state floras. We all look forward eagerly to subsequent volumes.

—Arthur Cronquist

INDEX NOTICE
To Librarians, Subscribers, and Binders

There is no index to Vol. 11 of THE MICHIGAN BOTANIST. Cumulative indexes each covering three volumes were issued at the ends of volumes 3, 6, and 9, with the suggestion that each 3-volume unit be bound as one. The next cumulative index, covering volumes 10-12, will appear in the October, 1973, issue.

Editorial Notes

Beginning January 1, 1973, the price for back issues will be a uniform $3.00 per volume or $.75 per number when available. (The first five volumes have been listed at $2.00 per volume.) Those contemplating ordering complete sets may do so for the remainder of this year at the old price. See inside front cover for details.

We regret that space limitations and an abundance of articles to be printed once again force postponement of "Michigan Plants in Print." The listings of new literature will be resumed as soon as possible.

Michigan Flora, Part I (reviewed on pp. 213-214 of this issue) became available June 20, 1972, and can be obtained from the chapters of the Michigan Botanical Club or by mail from Cranbrook Institute of Science, Bloomfield Hills, Michigan 48013 (Michigan residents add sales tax). It includes 723 distribution maps, 345 line drawings, and 46 color photos. Many members of the Michigan Botanical Club have helped in supplying records, advice, and now publicity for this volume; and the Club provided the color frontispiece of *Iris lacustris,* the dwarf lake iris.

The May number (Vol. 11, No. 3) was mailed May 9, 1972.

"Winter Wildflower" Project

The Committee wishes to thank all contributors of material to be considered for inclusion in the "Winter Wildflower" booklet. Without these contributions it would not be possible to produce the publication. It is through having an abundance of material and careful selection that we hope to be able to produce an interesting and varied booklet. We can use more photographs. They must be black and white, on paper suitable for reproduction. If you can get some more this fall, please send them to Helen V. Smith, University Herbarium, North University Building, Ann Arbor, Michigan 48104.

CONTENTS

The Genus *Helvella* in Michigan
Nancy Smith Weber 147

Analysis of a Terrestrial Lichen Population at
Grass Lake, Missaukee County, Michigan
Nancy M. Andersen & Raymond E. Hampton 202

Nature Education Feature–
Mnemonics for Learning Angiosperm Orders
John L. Blum 207

Four Interesting Moss Records from
Southwestern Ontario
William G. Stewart & F. S. Cook 212

Review–Michigan Flora, Part I 213

Index Notice 215

Editorial Notes 215

(On the cover: Tracings of beach grass,
Ammophila breviligulata, *in the sand at Sleeping Bear Dunes.*
Photo by Rudolf Schmid, October 5, 1969.)

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Vol. 12, No. 1

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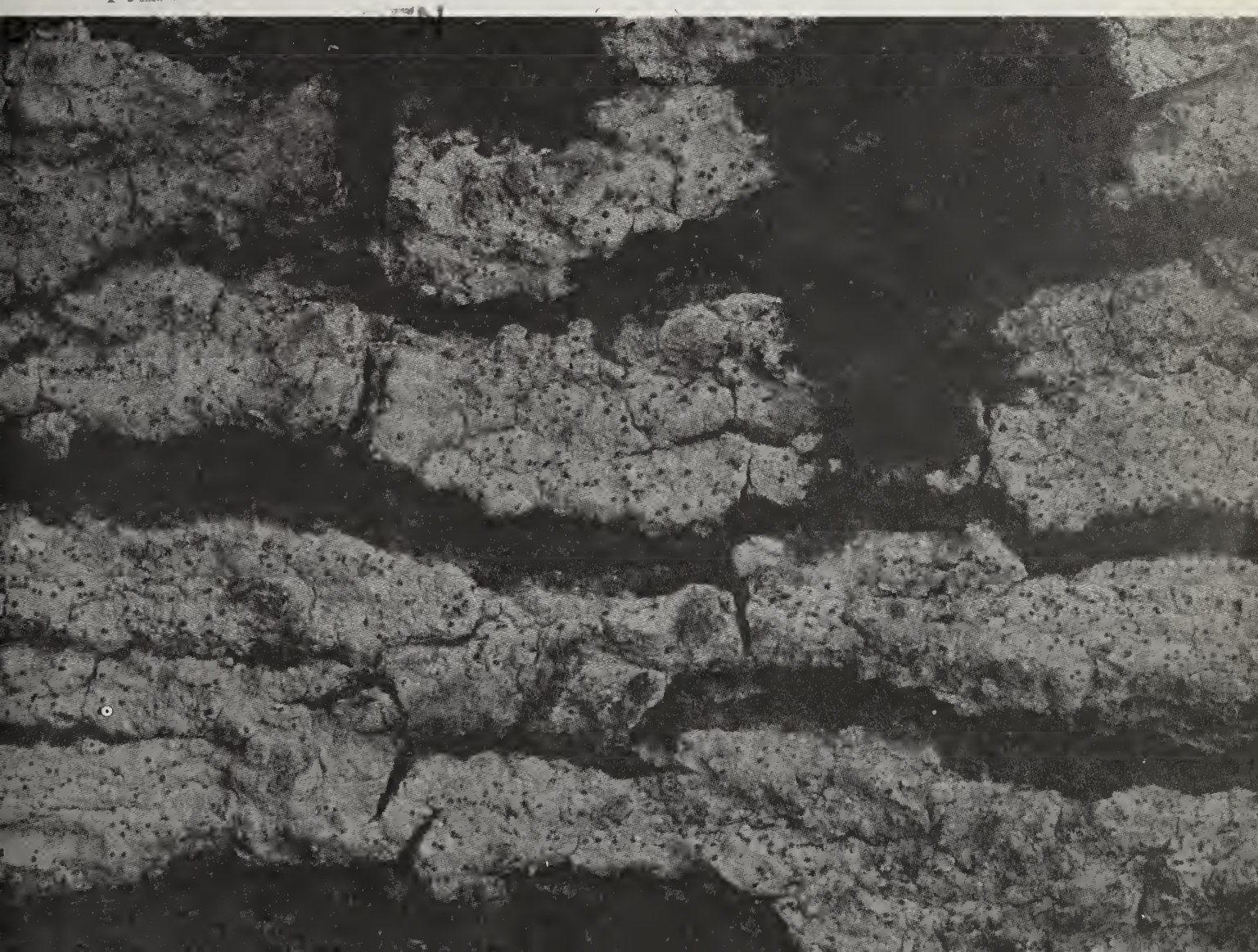

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Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager.

Address changes from Botanical Club members should be sent to appropriate chapter officers. Address changes for *non-member subscriptions only* should be sent to the business and circulation manager. *No* address changes should be sent to the editor.

Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow current style and the suggestions in "Information for Authors" (Vol. 9, p. 62; copies available from the editor).

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Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter) may send $3.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

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THE CORTICOLOUS PYRENOLICHENS OF THE GREAT LAKES REGION

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INTRODUCTION

The pyrenolichens and their non-lichenized allies are probably the least known group of lichens in North America. Even so, they are as abundant and widely distributed as any other group of lichens. They are inconspicuous and present considerable difficulties, both taxonomic and nomenclatural, but not much more so than most crustose lichens. I began a taxonomic survey of the corticolous pyrenolichens of the Great Lakes region in 1965, and a preliminary report was submitted as a thesis for the Master's Degree in late 1966. In the last five years the number of species included has almost doubled, and a number of taxonomic and nomenclatural problems have been resolved. As may be seen from the number of species still unnamed, problems still remain. Further, I anticipate that continued intensive collecting will bring additional species to light. This report should therefore not be considered as final, and is published with the hope of encouraging collection and study of this interesting group of lichens.

Although this treatment is intended primarily for the Great Lakes region, it includes most of the species found in the region of Gray's Manual. The Great Lakes region has been delimited as shown in Fig. 58. It includes Minnesota and Iowa for two reasons. First, a number of eastern species reach their western limit in those states. Secondly, because Bruce Fink collected extensively in this area between 1893 and 1902, it seemed desirable to include and revise his material, which was the basis for the only major publications dealing with a portion of the Great Lakes region (Fink, 1895-1903; 1910). The area includes eastern Ontario and adjacent Quebec in order to include the collections of John Macoun, one of North America's best collectors of pyrenolichens. For common and widely distributed species only Great Lakes collections have been cited, but the eastern North American distribution has been mapped. For the rarer species, all of the known North American collections are cited.

The survey has been confined to species on bark mainly in order to avoid *Verrucaria,* a difficult genus which grows on rock. The survey is also restricted to crustose species, excluding *Dermatocarpon tuckermanii* (Rav.) Zahlbr. and *Normandina pulchella* (Borr.) Nyl. which grow on trees but are squamulose. *Dermatocarpon tuckermanii* occurs in the western part of the Great Lakes region and has been adequately treated by Hale (1956). *Normandina pulchella* has not been previously reported from the Great Lakes region but has been collected a few times in Michigan. The general distribution of *Normandina* in North America is given by Culberson and Hale (1966).

The pyrenolichens are those in which the hymenium is enclosed and the spores are dispersed through a pore. This category includes both true perithecia with ascohymenial development and peritheciod ascostromata with ascolocular development. The former are generally associated with unitunicate asci and the latter with bitunicate asci. The status of the pyrenolichens in this respect is in a state of rapid change. The evidence to date is that the majority are ascolocular or borderline ascolocular/ascohymenial (Chadefaud, 1960; Janex-Favre, 1971; Riedl, 1962). In view of the current flux in suprageneric taxonomy, I have not grouped the genera into families. Instead, they are arranged alphabetically with a short discussion of probable relationships at the beginning of each genus. Authorities and dates of publication for families discussed are from Cooke and Hawksworth (1970). Six of the genera included here, in my opinion, are probably non-lichenized or contain non-lichenized species. They are included in a work on lichens because they are most likely to be collected and studied by those interested in lichens. Also, they have been traditionally treated as lichens.

Where material is inadequate or where further study is needed or in progress, I have chosen not to assign species names. There are nine species in four genera in this category. Although unnamed, these taxa have been included so that those using the key are not forced to try to fit them into an inappropriate species. Furthermore, it is hoped that inclusion will lead to the accumulation of sufficient material that they may be properly understood.

TERMINOLOGY

Normally, two different sets of terminology are used for ascohymenial and ascolocular pyrenolichens. Since many of the taxa treated seem to be on the border between the two and since this level of precision does not seem necessary for routine identification, I have chosen neutral terms. As much as possible they are in accordance with the definitions in Ainsworth (1961). *Thallus* is used for the vegetative mycelium in general and it may be lichenized or not. *Ascocarp* is a general term for any ascus-producing structure. When there is only a single outer layer, usually carbonized, covering or enveloping the hymenium, it has been called the *ascocarp wall.* If, as in *Pyrenula,* there is a definite stromatic shell from which an inner layer separates, I have called the outer layer the *involucrellum* and the inner the *exciple. Interthecial hyphae* are the sterile hyphae between the asci; together they form the hymenium. Ascus and spore shape are described in optical section. The colorless gelatinous outer layer found on many spores is abbreviated to *gelatinous sheath.* The central cavities of the spore are referred to as *lumina.* In *Pyrenula* some species have spores in which the septations consist entirely of endospore. Munk (1957) refers to this as false septation. In "true" septation the septum is presumably continuous with the outer spore wall. I refer to both types of spore as *septate.* Two sorts of asexually produced spores occur in pycnidia: *macroconidia,* whose septation and color parallel that of the perfect state, and *microconidia,* which are smaller, colorless, and non-septate and may possibly function as spermatia.

METHODS

Since most of the characters used to identify taxa are microscopic, the ascocarps must be sectioned or squashed. Larger ascocarps are best treated by moistening with a little water containing a wetting agent and sectioned with a razor blade under a dissecting microscope. With practice, sections little inferior to microtome sections can be made. Smaller ascocarps can be removed from the bark with a dissecting needle, placed on a slide, and squashed by tapping on the cover glass. The most satisfactory method for studying intact asci and spores, especially of species with large ascocarps, is to cut off about one-third of the ascocarp and then dissect out a portion of the hymenium, which then may be gently squashed on a slide without the interference of bark cells or carbonized wall fragments.

For routine study I find the best mounting medium is Lugol's Iodine (= IKI, iodine 1 gm, potassium iodide 1 gm, water 100 gm). It usually provides sufficient contrast to make details of interthecial hyphae, asci, and spores visible without chemically distorting them. In addition, substances in the hymenia of a number of species react with iodine providing additional taxonomic information. If desired, the material can then be checked for color reactions or cleared by the addition of 10-20% KOH to one edge of the cover slip and the iodine drawn out the other. The same method should be used to introduce HNO_3 under the cover glass with material mounted in water in order to examine the color reactions of the ascocarp wall. If IKI does not provide sufficient contrast to verify septations in spores and interthecial hyphae, the material may be mounted in aqueous phloxine. An additional advantage is that the slide may be cleared with KOH leaving only the protoplasm deeply stained. Spore sizes should be measured before addition of KOH since it causes some swelling. Spores are best measured and details, such as presence of a gelatinous sheath or ornamentation, are best observed with an oil immersion lens. The ornamentation of the spores of *Arthopyrenia cavata* and *A. finkii* can be stained with acetic cotton blue (Chadefaud, 1969) by heating just to the boiling point over a flame.

Examination of the thallus for the presence of algae is most conveniently done by mounting thin sections in lactophenol-cotton blue (Ainsworth, 1961) and warming gently. Algal cells, if present, are stained deep blue while the bark cells remain relatively unaffected.

Production of lichexanthone by the thallus may be detected by placing the specimen under long-wave ultraviolet light. Bright yellow or yellow-orange fluorescence indicates the presence of lichexanthone.

KEY TO SPECIES

1. Ascocarp wall green to greenish-black in section, reddish with HNO_3 2
1. Ascocarp wall brown to black in section, no reaction with HNO_3 4
   2. Spores with 3-5(6) transverse septa, two or more cells septate, 18-26 × (7)8-10 μ . . . . . *Mycoglaena meridionalis*
   2. Spores mostly with only 3-5 transverse septa, rarely a single cell septate 3
3. Spores pointed at both ends, one of the median cells enlarged, 18-23 × 6-8 μ; on *Myrica* or rarely *Abies* . . . . . *Mycoglaena myricae*

3. Spores with more rounded ends, cells all approx. equal, 18-30 × (5)6-8(9) μ; on *Quercus* . . . . . *Mycoglaena quercicola*
4. Spore walls thickened, lumina lenticular to subspherical (Figs. 40, 44, 52-57) 5
4. Spore walls not thickened, lumina cylindrical (Figs. 1-6) 14
5. Spores colorless 6
5. Spores some shade of brown 7
6. Ascocarps upright, in groups embedded in a pseudostroma; hymenium IKI−; spores 7-9-septate, 38-52 × 7-10 μ . . . . . *Trypethelium virens*
6. Ascocarps with ostiole lateral or at an angle, usually with a projecting neck, not grouped in a pseudostroma; hymenium IKI+ bluish; spores 18-27(30) × 7-10(12) μ . . . . . *Plagiocarpa hyalospora*
7. Ostiole vertical, not forming a projecting neck; hymenium IKI+ or IKI− 8
7. Ostiole lateral or angled, normally forming a projecting neck; hymenium IKI+ bluish 12
8. Spores submuriform (Fig. 53) or with more than three transverse septa . . . . . abnormal forms of *Pyrenula imperfecta*
8. Spores with only three transverse septa 9
9. Thallus UV+ yellow; hymenium IKI+ bluish, heavly inspersed with oil; spores with terminal lumina directly against outer spore wall, 13-22 × 7.5-11 μ. . . . . *Pyrenula neglecta*
9. Thallus UV−; hymenium IKI− or IKI+ pinkish orange; spores with terminal lumina separated from outer spore wall by a layer of endospore 10
10. Hymenium IKI+ pinkish orange, inspersed with small granules or droplets; spores 24-35(46) × 10-15(17) μ . . . . . *Pyrenula imperfecta*
10. Hymenium IKI−, not inspersed; spores 15-30 × 8-13 μ. 11
11. Thallus white or cream color; spores with lumina separated only by endospore, lacking septa continuous with outer wall (Fig. 43), 15-19(21) × 8-9(11) μ . . . . . *Pyrenula laevigata*
11. Thallus olivaceous; spores with septa between lumina continuous with outer spore wall (Fig. 55), 22-30 × 8-12 μ . . . . . *Pyrenula macounii*
12. Spores 3-septate, 30-40(45) × (12)14-16(18) μ . . . . . *Plagiocarpa phaeospora*
12. Spores up to 7-septate 13
13. Spores 55-80 × 20-26 μ. . . . . *Plagiocarpa macrospora*
13. Spores 30-42(45) × 12-15 μ . . . . . *Plagiocarpa septemseptata*
14. Spores some shade of brown 15
14. Spores colorless 20
15. Spores large, more than 30 × 12 μ 16
15. Spores smaller, less than 30 × 12 μ. 17
16. Spores muriform, 30-48(51) × (12)15-18(21) μ; ascocarp consisting of several multiascal chambers (Fig. 37) . . . . . *Mycoporum pycnocarpum*
16. Spores with transverse septa only 12
17. Spores 1-septate 18
17. Spores more than 1-septate. 19
18. Hyphae at base of ascocarp IKI+ violet; ascocarp wall usually entire; spores 10-17 × 6-7 μ; on *Betula papyrifera*. . . . . *Microthelia wallrothii*
18. Hyphae at base of ascocarp IKI−; ascocarp wall usually lacking below; spores 12-30 × 5-12 μ; on a variety of trees other than *Betula papyrifera* . . . . . *Microthelia micula*
19. Hymenium IKI+ bluish; spores usually 5-6-septate, lacking a gelatinous sheath, 18-24 × 5-9 μ; algal layer well developed; on a variety of trees . . . . . *Eopyrenula leucoplaca*
19. Hymenium IKI−; spores constantly 3-septate, with a thick gelatinous sheath, 15-24 × 6-8 μ; algal layer lacking; on *Populus tremuloides* . . . . . *Melanomma* sp.
20. Spores muriform or submuriform, with transverse and longtiduinal septa. . . 21
20. Spores with transverse septa only 25

21. Asci containing four spores; spores 35-45 × 12-13 μ . . . . . *Polyblastiopsis lactea*
21. Asci initially containing eight spores; spores up to 25 × 10 μ 22
22. Spores tapering at both ends, lacking a gelatinous sheath, 5-7-septate, 1-2 cells septate, 20-28 × 6-7.5 μ . . . . . *Arthopyrenia submuriformis*
22. Spores oblong, bluntly rounded at both ends, with evident gelatinous sheath 23
23. Asci cylindrical to narrowly obovate (Fig. 46); spores 5-7 × 1-2-septate, 17-25 × 7-10 μ . . . . . *Polyblastiopsis fallaciosa*
23. Asci oval or obovate (Figs. 48, 50) 24
24. Spores 17-19 × 6-7.5 μ; asci 35-45 × 18-30 μ . . . . . *Polyblastiopsis* sp. 1
24. Spores 25-30 × 7.5-10 μ; asci 65-75 × 25-30 μ . . . . . *Polyblastiopsis* sp. 2
25. Spores cylindrical-fusiform to acicular, in one or two bundles in the ascus which is little longer than the spores (Fig. 27) 26
25. Spores oval to fusiform, not in bundles; ascus several to many times the length of the spores 29
26. Spores under 30 μ in length. 27
26. Spores over 30 μ in length 28
27. Hymenium IKI−; spores often with pointed ends; on *Betula papyrifera*. . . . . *Leptorhaphis epidermidis*
27. Hymenium IKI+ orangish (occ. initially pale bluish); spores with rounded ends; on *Populus* . . . . . *Leptorhaphis atomaria*
28. Hymenium IKI−; on *Populus* . . . . . *Leptorhaphis contorta*
28. Hymenium IKI+ bluish; on *Prunus* and *Betula papyrifera* . . . . . *Leptorhaphis parameca*
29. Interthecial hyphae not branched and anastomosed; asci thin walled, not thickened at the tip, with a chitinoid apical ring when stained with Congo Red or Chlorazol Black. . . . . *(Porina)*
29. Interthecial hyphae branched and anastomosed (occ. not obviously so); asci thickened at the tip, never with a chitinoid ring 30
30. Spores more than 1-septate 31
30. Spores 1-septate. 36
31. Ostiole lateral or angled; hymenium IKI+ bluish . . . . . *Plagiocarpa hyalospora*
31. Ostiole vertical; hymenium IKI−. 32
32. Spores primarily 1-septate but becoming 3-septate; interthecial hyphae much branched and anastomosed; without septate macroconidia 33
32. Spores 3-7-septate; interthecial hyphae sparsely branched; often with septate macroconidia. 34
33. Ascocarps large, 0.3-0.5 mm in diam., dull, normally immersed in bark; spores 20-25 × 6-7.5 μ, with gelatinous sheath; algal layer absent . . . . . *Arthopyrenia* sp. 3
33. Ascocarps smaller, 0.2-0.3 mm in diam., shiny, normally superficial; spores 14-20 × 4.5-6 μ, lacking gelatinous sheath; algal layer well developed . . . . . *Arthopyrenia willeyana*
34. Spores 3-septate, 14-19 × 4.5-5 μ . . . . . *Arthopyrenia affinis*
34. Spores 5-7-septate 35
35. Mature spores 7-septate, cells never septate, 24-35 × 6-7.5 μ . . . *Arthopyrenia faginea*
35. Mature spores 5-7-septate, often with 1-2 cells septate, 20-28 × 6.7.5 μ . . . . . *Arthopyrenia submuriformis*
36. Ascocarp consisting of several-many multiascal chambers (Fig. 37 and see discussion p. 33); spores 20-26 × 5-7 μ . . . . . *Mycoporellum* sp.
36. Ascocarp with only a single multiascal chamber 37
37. Spores in a single row in the ascus, oblong or oval, with equal cells 38
37. Spores in more than one row in the ascus, or if in a single row, not oblong and oval 40
38. Spores 35-60 × 15-23 μ; ascocarps 0.5-1.0 mm in diam. . . . *Arthopyrenia finkii*
38. Spores less than 21 × 13 μ 39

39. Spore wall appearing rough; spores uniform in shape, bluntly rounded, 11-16.5 × 6-9.5 μ . . . . . *Arthopyrenia cavata*
39. Spore wall smooth; spores quite variable in shape, often somewhat pointed, 12-15 × 6-7 μ. . . . . *Arthopyrenia biformis*
    40. Hyphae at base of ascocarp IKI+ violet; spores 12-13.5 × 5-6 μ . . . . . *Arthopyrenia* sp. 1
    40. Hyphae at base of ascocarp IKI– 41
41. Spores ovate to elliptic ovate, ratio length to width ca. 2:1, 12-15 × 6-7 μ . . . . . *Arthopyrenia biformis*
41. Spores elliptical, fusiform or narrowly ovate, ratio length to width ca. 3:1 42
    42. Interthecial hyphae not obviously branched and anastomosed; spores often uniseriate, fusiform, 17-27 × 4.5-5 μ; pycnidia containing 1-septate macroconidia often present. . . . . *Arthopyrenia tenuis*
    42. Interthecial hyphae obviously branched and anastomosed; spores not uniseriate; lacking macroconidia 43
43. Asci obovate or obclavate; spores irregularly arranged 44
43. Asci cylindrical; spores tend to be biseriate 45
    44. Spores 18-22 × 5-7 μ, with a fairly thick gelatinous sheath; interthecial hyphae slender, filiform; on *Fraxinus* . . . . . *Arthopyrenia fraxini*
    44. Spores 15-20 × 4.5-6 μ, with thin gelatinous sheath; interthecial hyphae thick, short-celled, almost parenchymatous; on *Acer, Alnus, Betula,* and *Quercus* . . . . . *Arthopyrenia punctiformis*
45. Interthecial hyphae thick, short-celled, almost parenchymatous . . . . . *Arthopyrenia punctiformis*
45. Interthecial hyphae filiform 46
    46. Ascocarp large, 0.3-0.5 mm in diam., dull, usually immersed; spores 20-25 × 6-7.5 μ, becoming 3-septate with age . . . . . *Arthopyrenia* sp. 3
    46. Ascocarps smaller, ca. 0.25 mm in diam., usually superficial; spores less than 20 × 6 μ. 47
47. Algal layer well developed; ascocarps conical or subglobose, often shiny; spores without gelatinous sheath, 14-20 × 4.5-6 μ . . . . . *Arthopyrenia willeyana*
47. Algal layer lacking, ascocarp flattened; spores with a gelatinous sheath 48
    48. Spores 13-17 × 4-6 μ, usually with rounded ends; with ± thick gelatinous sheath; on *Pinus strobus* . . . . . *Arthopyrenia* sp. 4
    48. Spores 13-17 × 4-5 μ, usually with ± pointed ends, with a thin gelatinous sheath; on *Fraxinus* . . . . . *Arthopyrenia* sp. 2

ARTHOPYRENIA Massal.

Ricerch. Auton. Lich. 165. 1852. Type species uncertain.

Arthopyrenia is sometimes cited as having been emended by Müller Arg. (1862). Massalongo (1854a) removed some species from *Arthopyrenia* to *Acrocordia.* Müller's emendation consisted of returning *Acrocordia* to *Arthopyrenia* as a section and adding two new sections. One of these, *Pseudosagedia,* has had all of its species transferred to *Porina.* The other, *Leptorhaphis,* is generally recognized as a distinct genus. Thus *Arthopyrenia* is currently circumscribed either in the sense of Massalongo 1852 (incl. *Acrocordia*) or 1854 (excl. *Acrocordia*) and Müller should not be credited with any emendation.

The oldest name for this genus is *Leiophloea* (Ach.) S. F. Gray (1821). Riedl (1962) has restricted *Arthopyrenia* to species with spores more than 2-celled as opposed to *Leiophloea,* with 2-celled spores. This removed the necessity for conservation of *Arthopyrenia,* if retained in the currently

accepted sense including both 2-celled and more than 2-celled species. Clements (1909) did essentially the same but provided the name *Pyrenillium* for the species with 2-celled spores. Both *Leiophloea* and *Pyrenillium* have been typified with *Arthopyrenia analepta* (Ach.) Massal. In my opinion these treatments would remove species, which are in all other respects extremely closely related, into separate genera, i.e., *A. taylorii* (Nyl.) Mudd and *A. tenuis* would be separated from the rest of the *A. faginea* group. Therefore I feel obliged to reject Clements' and Riedl's treatments and propose conservation of *Arthopyrenia.* Clements (1909) chose *A. pyrenuloides* (Fée) Müll. Arg. as the type species but this species was not included in Massalongo's original publication. Fink (1910) selected *A. analepta,* presumably since it is the first species treated in Massalongo's original publication. Riedl (1962) chose *A. rhyponta* (Ach.) Massal. This species seems to be somewhat atypical of the majority of species included in *Arthopyrenia* and not the best possible lectotype, although it is an acceptable one.

Arthopyrenia is treated here as an artificial genus for species with colorless, transversely septate spores and bitunicate asci. Developmental studies by Janex-Favre (1971) have shown two distinct types within *Arthopyrenia* s. lat. One is represented by *A. fallax* (Nyl.) Arn. and *A. submicans* Arn., the other by *A. conoidea* (Fr.) Zahlbr. and *A. sublitoralis* (Leight) Arn. (= *A. halodytes* (Nyl.) Arn.). Janex-Favre suggests the first group belongs in the family Microthyriaceae of the Pleosporales, but Riedl (1970) feels that the structure of *A. fallax* is not typical of the Microthyriaceae. Janex-Favre relates the second group to *Pyrenula nitida* (Weig.) Ach., and *Arthopyrenia conoidea* is already often included in a segregate genus, *Acrocordia* (Poelt, 1969; Riedl, 1970). *Arthopyrenia halodytes* seems to me to belong in a loose grouping with *A. biformis* and *Strigula.* A fourth discordant group centered around *A. fagina* has been recognized by Vězda (1968), who related it to *Acrocordia* and *Strigula.* Of the species in the Great Lakes region *A. fraxini, punctiformis,* and spp. 1-4 belong in the *A. fallax* group (= *Arthopyrenia* s. str.); *A cavata* and *finkii* in *Acrocordia; A. biformis* and *willeyana* in the third group. *A. affinis, submuriformis,* and *tenuis* are close to *A. faginea.* The first group is apparently non-lichenized; the others are lichenized.

Many authors (e.g., Hale & Culberson, 1970, and Kreisel, 1969) recognize a family Arthopyreniaceae Wats. (1929). However, if one includes *Mycoporum* and *Mycoporellum* in the family, as I feel is reasonable, the earliest name for a "lichen family" is Mycoporaceae Zahlbr. (1903), as Riedl (1962) has shown. If one does not wish to distinguish families on the basis of lichenization, *Arthopyrenia* and related genera would seem to belong in the Pleosporaceae Wint. (1885). I prefer this latter treatment, especially since many of the genera, e.g., *Arthopyrenia* s. str., do not seem to be lichenized.

Whether *Acrocordia* and the other two lichenized groups should be included in the Pyrenulaceae Zahlbr. (1903) or in a separate family remains to be decided. The oldest name, whether combined with the Pyrenulaceae or not, is the Strigulaceae Fr. (1825).

Arthopyrenia affinis (Massal.) comb. nov.

Sagedia affinis Massal., Mem. Lich. 138. 1853. *Porina affinis* (Massal.) Zahlbr., Oesterr. Bot. Zeitschr. 51: 277. 1901. Type collection not seen.

The following description has been modified from Keissler (1938).

Thallus thin, grayish, smooth. *Trentepohlia* abundant.

Ascocarps crowded, occasionally 2-3 confluent, brown-black, hemispherical to subglobose, not much immersed, 0.2-0.5 mm in diameter. Ascocarp wall brown above, colorless below, 30-35 μ thick, thinner below. Hymenium IKI−. Interthecial hyphae ca. 1 μ thick, filamentous, septate, rarely branched. Asci cylindrical or cylindrical-clavate, slightly thickened at the tip, inner surface often with a small indentation, 50-90 × (5)7-12 μ. Spores eight in the ascus, biseriate to quite irregular, colorless, oblong, 3-septate, not constricted at the septa, or slightly constricted at the median septum, without gelatinous sheath, 14-19 × 4.5-5 μ.

Swinscow (1965) has pointed out that this species should be transferred to *Arthopyrenia.* It is characterized by small 3-septate spores and almost unbranched interthecial hyphae. European specimens often have pycnidia with 3-septate macroconidia.

Arthopyrenia affinis has not previously been recorded from North America.

Illustrations: Fig. 1; Swinscow, 1963, Fig. 13.

Exsiccati examined: Mass. 350 (FH).

Specimens seen: Canada. ONTARIO: Carleton County, Ottawa, *Macoun,* 12 Apr. 1895 (FH).

Arthopyrenia biformis (Borr.) Massal., Framm. Lich. 26. 1855.

Verrucaria biformis Borr. in Hook. & Sowerby, Suppl. Engl. Bot. 1: pl. 2617, f. 1. 1831. Type collection not seen.

Thallus well developed, whitish or grayish. *Trentepohlia* abundant.

Ascocarps scattered to crowded, occasionally fused, hemispherical to subglobose, one-third to almost completely immersed, 0.3-0.6 mm in diameter. Ascocarp wall brown-black, lacking below, 50-100 μ thick. Hymenium IKI−. Interthecial hyphae ca. 1 μ thick, regular, filamentous, septate, branched and anastomosed. Asci cylindrical, thickened at the tip, inner surface often with a hemispherical indentation, 100-115 × 11-13 μ. Spores initially eight in the ascus but several may not develop, uniseriate to irregularly biseriate, colorless, rather variable in shape, oval, ovate or occasionally almost elliptical, 1-septate, not constricted at the septum, septum slightly eccentric, without a gelatinous sheath, 12-16 × 6-7 μ.

Pycnidia black, hemispherical, ca. 0.1-0.2 mm in diameter. Microconidia colorless, globose, or subglobose, simple, 2-3 μ in diameter.

Arthopyrenia biformis is likely to be confused with *A. cavata* but differs in having unornamented, more pointed spores and a more variable arrangement of the spores in the ascus. Also, the spore size of *A. biformis* is probably slightly smaller than in *A. cavata,* but I have not compiled enough measurements to verify this.

Arthopyrenia biformis is rare in the Great Lakes region, but it is common on both coasts of North America. Apparently, it is replaced inland

by the closely related *A. willeyana,* which is rarer in coastal regions. *A. biformis* occurs on *Quercus* in the Great Lakes region and also on *Acer, Betula, Carya,* and *Isomeris* elsewhere.

Illustrations: Figs. 3-4; Swinscow, 1970, Fig. 4. Distribution: Fig. 58.

Exsiccati examined: Krypt. Vind. 375 (FH, US); Leight. 100 (FH, US); Merr. I:147 (CAN, FH, US), II:164 (CAN, US).

Specimens seen (Great Lakes only): United States. ILLINOIS: Cook County, *Calkins* (FH, MICH, Thomson, US). MICHIGAN: Washtenaw County, NW of Crooked Lake, *Harris 869* (MSC).

Arthopyrenia cavata (Ach.) comb. nov.

Verrucaria cavata Ach., Syn. Lich. 91. 1814. Holotype: Helvetia, (*Schleicher*?) *442a* (H; hb. Ach.).

Thallus endophloeodal, pale gray to whitish, slightly roughened to smooth. *Trentepohlia* abundant, well-developed, forming short chains.

Ascocarps scattered, dark brown to black, occasionally somewhat shiny, hemispherical, one-third to two-thirds immersed, 0.3-0.5 mm in diameter. Ascocarp wall entire, brown and containing bark cells above, mostly hyaline below and appearing dimidiate, 60-80 μ thick above, thinner below. Hymenium IKI−. Interthecial hyphae ca. 1 μ thick, not obviously septate, branched and anastomosed. Asci cylindrical, inner wall with an obvious subspherical indentation, 80-115 × 9-10 μ. Spores eight in the ascus, uniseriate, hyaline, oblong to somewhat elliptical, 1-septate with approximately equal cells, mostly not constricted at the septum, wall ornamented with minute warts, 11-16.5 × 6-9.5 μ (11-13 × 6-7.5 μ in the type).

In 1966, while in Helsinki, H. A. Imshaug kindly prepared slides of some of the pyrenocarpous lichen material in the Acharian herbarium. *Verrucaria cavata* Ach. turned out to be identical with material which I had previously named *Arthopyrenia sphaeroides* (Wallr.) Zahlbr., characterized by small spores. However, Swinscow (1970) has examined the type of *A. sphaeroides* and found it to be a synonym of *A. gemmata* (Ach.) Massal., which has larger spores. He did not recognize the existence of a small-spored species in sect. *Acrocordia* distinct from *A. gemmata* and *A. biformis.* Swinscow doubtfully placed *A. biformis* in sect. *Acrocordia.* In my opinion it does not belong in sect. *Acrocordia.* The most easily defined distinction is that the spore wall is smooth in contrast to members of sect. *Acrocordia,* such as *A. cavata,* which have an ornamented spore wall. *Arthopyrenia cavata* is generally smaller in all respects than *A. gemmata,* which does not occur in North America. Specifically, *A. cavata* has a mean spore size of 13.8 ± 1.3 × 7.8 ± 0.8 μ (176 spores from 35 collections) and *A. gemmata* 22.1 ± 2.5 × 10.8 ± 1.0 μ (274 spores from 52 collections). If two standard deviations are used to give the range then *A. cavata* has spores 11-16.5 × 6-9.5 μ and *A. gemmata* 17-27 × 9-13 μ.

Arthopyrenia cavata has not been generally recognized in North America. It is found in herbaria under *A. gemmata, A. alba,* or *A. biformis.* The species, as represented in American herbaria, seems less common in Europe than *A. gemmata.* In the Great Lakes region it is quite common and grows on *Fraxinus, Populus, Quercus alba,* and *Thuja.*

Illustrations: Fig. 4.

Exsiccati examined: Fr. 274 (MSC); Krypt. Vind. 2152 (FH, US); Malbr. 398 (MSC); Rab. 29 (FH-Tuck 4062).

Specimens seen: Canada. QUEBEC: County unknown, Gaspé Peninsula, *Eckfeldt,* 1880-1883 (MICH), *Macoun 193* (FH-Tuck 4024), 12 Aug. 1882 (US), Aug. 1882 (CAN).

United States. IOWA: Boone County, The Ledges, *Fink,* 27-28 July 1903 (MICH); Fayette County, Fayette, *Fink,* July 1894 (FH, LD, MICH, MIN, WIS). MAINE: Cumberland County, Brunswick, *Merrill,* 23 Aug. 1911 (FH). MASSACHUSETTS: County unknown, near Boston, *Tuckerman* (FH-Tuck 4024). MICHIGAN: Delta County, NW of Isabella, *Harris 4115, 4256* (MSC); Emmet County, S of Levering, *Harris 3633* (MSC); Iosco County, Iargo Springs, *Harris 4014* (MSC); Keweenaw County, Isle Royale, Ryan Island, Siskowit Lake, *Lowe 863* (FH, MICH); Lake County, W of Irons, *Harris 3872, 3877, 3895-C* (MSC); Newaygo County, near Hesperia, *Imshaug 21196* (MSC). MINNESOTA: Blue Earth County, Mankato, *Fink 109* (MIN); Yellow Medicine County, Granite Falls, *Fink 513* (MIN).

Arthopyrenia faginea (Schaer.) Swinsc., Lichenologist 3: 72. 1965.

Sagedia faginea Schaer., Enum. Crit. Lich. Europ. 208. 1850. *Porina faginea* (Schaer.) Arn., Flora 68: 166. 1885. Type collection not seen.

Thallus very well-developed, greenish- or bluish-gray, smooth. *Trentepohlia* abundant.

Ascocarps scattered to crowded and occasionally 2-3 confluent, immersed or if emergent covered by a thin layer of thallus, globose or subglobose, 0.2-0.4 mm in diameter. Ascocarp wall entire, brown to blackish above, colorless below, 30-70 μ thick, somewhat thinner below. Asci cylindrical, thickened at the tip, inner surface with a small, distinct indentation, 80-110 × 13-15 μ. Spores eight in the ascus, biseriate or subbiseriate, colorless, fusiform, 7-septate, slightly constricted at the septa, especially the median one, without gelatinous sheath, 24-35 × 5-7.5 μ.

Arthopyrenia faginea was first recognized from North America (Queen Charlotte Islands) by Brodo. Subsequently, I have collected it several times in Michigan. In the field it appears as a featureless gray crust on the base of *Thuja,* and therefore it is perhaps not often collected. It is distinguished by its well-developed thallus usually growing over mosses and by 7-septate spores, with the cells never septate, over 25 μ in length. In Europe this species often has pycnidia with 7-septate macroconidia but macroconidia have not been found in American material.

Arthopyrenia faginea in Michigan is usually, at least partly, over mosses (extending on to the bark) on the bases of *Thuja* but once on mosses on the base of *Fagus.*

Illustrations: Fig. 5; Swinscow, 1963, Fig. 14; Vězda, 1968, Fig. 27.

Exsiccati examined: Hepp 464 (FH), 708 (FH); Krypt. Vind. 180 (FH); Rab. 623 (MICH).

Specimens seen: Canada. BRITISH COLUMBIA: Queen Charlotte Is., Graham Is., *Brodo 11662* (CAN).

United States. MICHIGAN: Alger County, W of Kingston Lake, *Harris 6052* (MSC); Clare County, N of Long Lake, *Harris 7655* (MSC); Dickinson County, O'Neil Lake, *Harris 7447, 7534, 7567, 7576* (MSC).

Arthopyrenia finkii Zahlbr., Cat. Lich. Univ. 1: 306. 1921.

Pyrenula megalospora Fink, Minnesota Bot. Stud. 2: 329. 1899. (non *Arthopyrenia megalospora* Lönnr., Flora 41: 634. 1858.)

Arthopyrenia macrospora Fink, Contr. U.S. Natl. Herb. 14: 237. 1910. (non *Arthopyrenia macrospora* J. Stein, Ann. Naturhist. Hofmus. 23: 109. 1909). Lectotype: Mankato, Minnesota, *Fink 209,* 1 July 1899 (MICH). Isolectotype in MIN.

Thallus endophloeodal, pale gray to whitish, smooth with a hyaline cortex-like layer 10-20(35) μ thick. *Trentepohlia* abundant.

Ascocarps scattered, dark brown to blackish, dull, subspherical, 0.5-1.0 mm in diameter, one-third to almost completely immersed. Ostiole often at the end of a short neck, often displaced from the vertical. Involucrellum dark brown to pale yellow brown, usually dimidiate, consisting largely of bark cells or bark cell remnants, especially in the lower part, 50-75 μ thick. Exciple colorless, entire, 25-40 μ thick, thinner below. Hymenium IKI−. Interthecial hyphae ca. 1 μ thick, not obviously septate, branched and anastomosed. Asci long-cylindrical, tip thickened, inner wall usually with a distinct subglobose indentation, 150-250 × 15-25 μ. Spores initially eight in the ascus but 1-4 often aborting, uniseriate, colorless, oblong, elliptical or rarely somewhat fusiform, 1-septate with approximately equal cells, slightly constricted at the septum especially in age, wall ca. 2 μ thick, consisting of two layers, the outer ornamented with minute warts, 33-48(60) × 15-23 μ.

Arthopyrenia finkii has the largest spores and ascocarps of an apparent series within the section *Acrocordia* which have a similar spore, ascus, and hymenial type, differing primarily in size. *Arthopyrenia cavata* is the smallest member; *A. gemmata* (Ach.) Massal. is intermediate. *Arthopyrenia gemmata* apparently does not occur in North America. All of the collections thus far examined have been incorrectly identified.

Pyrenula gemmata var. *macrocarpa* (Körb.) Willey, Enum. Lich. New Bedford 38. 1892. is *A. finkii* and *A. macrocarpa* (Körb.) Zahlbr. should be removed from the North American flora.

Arthopyrenia finkii occurs from southern Minnesota to western Pennsylvania and on the east coast in Maine, Massachusetts, Maryland, and Virginia. Its distribution seems related to oak forests (Fig. 6), as does that of *A. submuriformis* and *A. tenuis.* It has been collected on *Quercus alba* and *Ulmus americana.*

Illustration: Fig. 6. Distribution: Fig. 59.

Specimens seen (Great Lakes only): United States. IOWA: Jones County, Wapsipinicon, *Imshaug 28092* (MSC). MICHIGAN: Kalamazoo County, N of Augusta, *Harris 141* (MSC); Washtenaw County, NW of Crooked Lake, *Harris 870-A* (MSC). MINNESOTA: Blue Earth County, Mankato, *Fink 112* (MIN), *209* (MICH, MIN); Yellow Medicine County, Granite Falls, *Fink 381* (MIN, US), *576* (MICH, MIN). WISCONSIN: Green County, *Hale 1250* (US); Green Lake County, *Hale 1251* (WIS); Vernon County, *Hale 1223* (WIS), Wild Cat Mtn. St. Park, *Thomson 12818* (WIS).

Arthopyrenia fraxini Massal., Ricerch. Auton. Lich. 167. 1852.

Type collection not seen.

Thallus non-lichenized, indicated by discolored area on bark. No algae seen.

Ascocarps scattered, blackish, dull, hemispherical, slightly immersed, 0.3-0.4 mm in diameter, 0.1-0.2 mm in height. Ascocarp wall lacking below, 30-40 μ thick. Hymenium IKI−. Interthecial hyphae ca. 2 μ thick, irregular, branched and anastomosed. Asci obovate to obclavate with a short broad stipe, thickened at the tip, 55-70 × 20-25 μ. Spores eight in the ascus, irregularly arranged, oblong to oblong-elliptical, 1-septate, constricted at the septum, lower cell usually slightly longer and narrower than upper, with a thick gelatinous sheath, 18-22 × 5-7 μ (without sheath).

Arthopyrenia fraxini is intermediate between *A. punctiformis* and *A. fallax*. Its interthecial hyphae are not parenchymatous as in *A. punctiformis* but are less uniform and less filamentous than in *A. fallax*. It differs in ascus shape from *A. fallax*, which has cylindrical or oblong-elliptical asci. Its spores are very similar to those of *A. fallax* but differ from those of *A. punctiformis*, which are slightly smaller and have a less well-developed gelatinous sheath.

Arthopyrenia fraxini is new to North America. It apparently is confined to smooth, young *Fraxinus* bark, both here and in Europe.

Illustrations: Figs. 7-8.

Exsiccati examined: Anzi It. 385 (FH-Tuck 4071); Hepp 453 (FH-Tuck 4066); Mass. 298A, B, 299 (FH-Tuck 4070); Merr. I: 281 (US), II: 20 (MICH, MSC, US, WIS); Rab. 146 (FH-Tuck 4071, MICH).

Specimens seen: United States. MICHIGAN: Keweenaw County, Lake Medora, *Thomson 3212* (Thomson, WIS). NEW YORK: Oneida County, Oneida, sine coll. (FH). OHIO: Franklin County, Georgesville, *Bogue*, 1895 (MICH, MSC, US, WIS).

Arthopyrenia punctiformis Massal., Ricerch. Auton. Lich. 168. f. 335. 1852.

Type collection not seen.

Massalongo, in his publication of this name, clearly is not transferring a species as conceived by an earlier author since he does not cite any basionym at the species level, referring only to *Verrucaria punctiformis* Auctor. Thus the priority of this name must date from 1852 and not from Persoon (1794) or Schrank (1789), whose species Massalongo is often cited as transferring into *Arthopyrenia*. Transfer of the latter two names into *Arthopyrenia*, of course, is precluded as they would be later homonyms of Massalongo's name.

Thallus non-lichenized, bark often discolored around ascocarps. No algae seen.

Ascocarps scattered or rarely clustered and fused, dark brown or black, circular to elliptical, hemispherical, 0.1-0.25 mm in diameter, initially covered by a thin layer of bark but soon entirely uncovered. Ascocarp wall lacking below, 20-30 μ thick. Hymenium IKI−. Interthecial hyphae thick, 2-3 μ, septate and much branched with an almost parenchymatous appearance, often appearing moniliform in KOH. Asci obclavate, clearly broadest below the middle, tip thickened, 45-60 × 15-20 μ. Spores eight in the ascus, irregularly arranged, hyaline, 1-septate, the cells usually somewhat unequal with the lower one longer and narrower, usually not constricted at the septum, occasionally with a thin gelatinous sheath, 15-20 × 4.5-6 μ.

Arthopyrenia punctiformis seems to be widely distributed but rarely collected due to its small size. It occurs on smooth, usually young bark of *Acer rubrum*, *Alnus*, *Betula*, and *Quercus*.

Illustrations: Figs. 9-10; Vězda, 1968, Fig. 8.

Specimens seen (Great Lakes only): Canada. ONTARIO: Carleton County, Ottawa, *Macoun,* 30 Apr. 1897 (CAN), Rideau River, *Macoun,* 30 Apr. 1887 (CAN, FH).

United States. MICHIGAN: Alger County, Deerton, *Lowe 1929* (FH), E of Kingston Lake, *Harris 661* (MSC); Charlevoix County, Beaver Island, *Imshaug 27485* (MSC); Keweenaw County, Isle Royale, Angleworm Lake, *McFarlin & Brown 580a* (FH, MICH, US).

Arthopyrenia submuriformis sp. nov.

Arthopyreniae fagineae similis sed differt sporis frequenter submuriformibus, 1-2 loculis cum septo longitudinali, 20-27 × 6-7.5 μ.

Holotype: Cum. I: 299 (as *Pyrenula quinqueseptata*), Pennsylvania, West Chester, on bark of hickory, *Windle,* July 1898 (MSC). Isotypes in CAN, MICH, & US as Cum. I: 299; in FH, FH-Riddle, MICH, & MSC as Cum. II: 250.

Thallus endophloeodal, light gray to whitish, smooth. *Trentepohlia* abundant.

Ascocarps scattered to clustered and partially fused, separating walls sometimes not carbonized, black, occasionally shiny, hemispherical, mostly ca. one-third immersed, rarely almost entirely immersed, 0.3-0.45 mm in diameter, 0.15-0.25 mm in height. Involucrellum brown, lacking below, 24-30 μ thick. Exciple colorless, entire, ca. 15-20 μ thick. Hymenium IKI−. Interthecial hyphae ca. 1-2 μ thick, septate, rarely branched and anastomosed. Asci cylindrical to clavate-cylindrical, thickened at the tip, inner surface with a small indentation, 75-95 × 13-16 μ. Spores eight in the ascus, biseriate or subbiseriate, colorless, fusiform, 5-7 transversely septate, often with 1-2 cells septate, not or only slightly constricted at the septa, without a gelatinous sheath, 20-27 × 6-7.5 μ.

Pycnidia often present, black, ca. 0.1-0.2 mm in diameter. Macroconidia colorless, cylindrical, mostly 7-septate, 20-23 × 4-4.5 μ.

The tendency of the spores of *Arthopyrenia submuriformis* to become longitudinally septate would lead one to thick of *Polyblastiopsis.* However, ascocarp structure, ascus, spore, and macroconidia type are identical with *Arthopyrenia faginea.* It differs from *A. faginea* by its smaller, submuriform spores.

Arthropyrenia submuriformis has not been collected in Michigan. In fact, the species apparently has not been collected since early in the century. The only substrates reported are *Carpinus, Carya,* and old wood.

Illustrations: Figs. 11-12.

Exsiccati examined: Cum. I: 299 (CAN, MICH, MSC, US), II: 250 (FH, FH-Riddle, MICH, MSC).

Specimens seen: United States. ILLINOIS: Menard County, Athens, *Hall* (FH-Tuck 4023, MICH). IOWA: Fayette County, *Fink,* June 1893 (FH, LD, MIN, WIS), June 1894 (MICH, Thomson), 1895 (CAN, US), 1896 (FH, US). MINNESOTA: Beltrami County, Red Lake, *Fink 887* (MICH, MIN); Blue Earth County, Mankato, *Fink 32* (MIN), *71* (MICH, MIN), *208* (MICH, MIN); Yellow Medicine County, Granite Falls, *Fink 470* (MIN). NEW HAMPSHIRE: County unknown, White Mtns., *Oakes*? (FH-Tuck 3987). NEW JERSEY: sine loc., Austin (US). PENNSYLVANIA: Chester County, sine loc., *Michener 155* (FH-Tuck 3987, MICH), *230* (FH-Tuck 3987, MICH), West Chester, *Windle,* July 1898 (CAN, FH, FH-Riddle, MICH, MSC, US).

Arthopyrenia tenuis sp. nov.

Arthopyreniae taylori (Carroll ex Nyl.) Mudd affinis sed ascocarpis majoribus, 0.4-0.5 mm diam., ascis anguste cylindraceis et sporis uni- vel biseriatis, 17-25 x 4-5.5 μ.

Holotype: Iowa, Fayette County, *Fink*, 1896 as *Arthopyrenia hyalospora* (MSC). Isotypes in FH, MICH, MIN, & US.

Thallus endophloeodal, pale gray, smooth. *Trentepohlia* present but not abundant, well-developed.

Ascocarps scattered or crowded and occasionally 2-3 fused, black, usually shiny, hemispherical to slightly conical, ca. one-third immersed, 0.4-0.5 mm in diameter, 0.2-0.35 mm in height. Ascocarp wall entire or lacking below, brown above, 30-60 μ thick, thinner and colorless below. Hymenium IKI−. Interthecial hyphae ca. 1-2 μ thick, septate, occasionally branched but apparently not anastomosed. Asci narrowly cylindrical, slightly thickened at the tip, inner surface often with an indistinct indentation, 80-135 x 8-12 μ. Spores eight in the ascus, obliquely uniseriate to biseriate, fusiform, 1-septate with equal or unequal cells, slightly constricted at the septum, occasionally slightly bent, without a gelatinous sheath, 17-27 x 4-5.5 μ.

Pycnidia usually abundant, brown to black, ca. 0.1-0.2 mm in diameter. Conidia of two types, once found in the same pycnidium, but normally in separate pycnidia. Microconidia hyaline, elliptic, simple, ca. 3-4 x 1.5 μ. Macroconidia hyaline, cylindrical, 1-septate, 14-18 x 3-4 μ.

Arthopyrenia tenuis is distinguished by its narrow spores and almost unbranched paraphyses. Closely related *A. taylorii* differs in shorter obclavate asci and irregularly arranged spores. *Arthropyrenia tenuis* is also related to *A. faginea* and *A. submuriformis*. The distribution of *A. tenuis* is strikingly similar to that of *A. submuriformis*. The only substrates reported are *Fraxinus* and *Ulmus*.

Illustrations: Figs. 13-15.

Specimens seen: United States. ILLINOIS: County unknown, *Hall* (FH-Tuck 4048), *Hall,* 1871 (FH-Tuck 3987); Fulton County, Canton, *Wolf* (US); Menard County, Athens, *Hall,* 1878 (MIN). IOWA: Boone County, The Ledges, *Fink*, 27-8 July 1903 (MICH); Fayette County, *Fink,* 1896 (FH, MICH, MIN, MSC, US); Jones County, Wapsipinicon, *Imshaug 28103* (MSC). MARYLAND: Baltimore County, Beaman's Run, *Plitt,* 1 Dec. 1911 (FH, US), The Caves, *Plitt,* 1 Mar. 1910 (FH, US); Calvert County, Chesapeake Beach, *Plitt,* 19 July 1911 (FH). MASSACHUSETTS: Bristol County, New Bedford, *Willey* (US). MINNESOTA: County unknown, Minneapolis, *Fink* 1896 (CAN); Beltrami County, Red Lake, *Fink* (CAN, FH, LD, MICH, MSC). PENNSYLVANIA: Chester County, *Michener* (FH-Tuck 4028, MICH). WISCONSIN: Vernon County, Wild Cat Mtn. St. Park, *Thomson 12817* (WIS).

Arthopyrenia willeyana sp. nov.

Arthopyreniae biformis affinis, sed differt ascocarpis minoribus, 0.25 mm diam., sporis saepe 3-septatis, 16-20 x 5-6 μ, et microconidiis oblongis vel ovatis, 2-3 x 1-1.5 μ.

Holotype: Michigan, Iosco County, north of Tawas City, *Harris 818* (MSC). Isotypes in B, BM, CAN, COLO, Duke, H, Harris, LD, MIN, S, TNS, UPS, US, Vězda, & WIS.

Thallus endophloeodal, whitish, gray or gray-green, smooth. *Trentepohlia* abundant, well-developed.

Ascocarps crowded to scattered, black, shiny, subconical to subglobose, initially immersed but becoming superficial, 0.15-0.25 mm in diameter, 0.1-0.2 mm in height. Ascocarp wall brown-black, 30-50 μ thick above, thinner and colorless below, or lacking below. Hymenium IKI−. Interthecial hyphae ca. 1 μ thick, septate, branched and anastomosed. Asci clavate-cylindrical, not much thickened at the tip, inner surface with an indistinct indentation, 55-90 × 12-15 μ. Spores eight in the ascus, biseriate, colorless, narrowly ovate to fusiform, 1-septate, occasionally 3-septate, cells unequal, the upper broader and up to twice as long as the lower, lacking a gelatinous sheath, 14-20 × 4.5-6 μ.

Pycnidia black, ca. 0.1 mm in diameter. Microconidia colorless, oblong or oval, 2-3 × 1-1.5 μ.

Arthopyrenia willeyana is distinguished by the small shiny ascocarps and spores with unequal cells, often becoming 3-septate. The number of 3-septate spores present is variable. They are completely lacking in some collections, present in small numbers in many, and predominate in a very few.

Arthopyrenia willeyana is one of the most common species in the Great Lakes region. It is found in a variety of habitats and seems to be one of the most adaptable pyrenolichens. It is most commonly on *Quercus alba* and *Ulmus americana* but also has been collected on *Acer saccharum, Betula lutea, Carya, Fraxinus, Juglans, Liquidambar, Platanus, Populus* spp., *Quercus* spp., *Robinia, Tilia, Thuja,* and old wood.

Illustrations: Figs. 16-18. Distribution: Fig. 60.

Specimens seen (Great Lakes only): United States. IOWA: Dickinson County, Lake Okoboji, *Thomson 10940* (WIS); Jones County, Wapsipinicon, *Imshaug 28093, 28105-A* (MSC). MICHIGAN: Alger County, Kingston Lake, *Harris 652, 6023* (MSC); Barry County, Otis Lake, *Harris 310* (MSC), Shaw Lake, *Harris 464* (MSC); Berrien County, Warren Woods, *Harris 215, 216-B, 219* (MSC); Cass County, Russ Forest 7 mi S of Decatur, *Harris 5869, 5871, 5877, 5879-A, 5880, 5882, 5883* (MSC); Clare County, Frost Lake, *Harris 3761* (MSC), N of Long Lake, *Harris 3773* (MSC), W of Farwell, *Harris 997, 998* (MSC); Clinton County, hwy. M-78 near Shiawassee Co. line, *Harris 3742* (MSC), Rose Lake St. Game Area, *Harris 956, 963, 3985* (MSC), W of Grand Ledge, *Harris 3756* (MSC); Delta County, NW of Isabella, *Harris 4233, 4243, 4249* (MSC); Dickinson County, O'Neil Lake, *Harris 7425* (MSC); Eaton County, S of Eaton Rapids, *Harris 896* (MSC), near Vermontville, *Imshaug 29252, 29256* (MSC); Emmet County, Harbor Springs, *Mains 173* (MICH); Ingham County, Holt Bog, *Harris 922* (MSC), Mich. State University Campus, *Harris 45-A, 46, 49, 53-B, 57, 69, 72, 85, 89, 905, 906, 908, 915* (MSC); Iosco County, Iargo Springs, *Harris 818, 3792, 3811, 4016* (MSC); Kalamazoo County, Kellogg Forest N of Augusta, *Harris 264, 265, 266, 272, 274, 317 318, 319, 320, 326, 415, 416, 418, 511, 513, 514* (MSC), W of Richland, *Harris 114, 116, 118, 122, 132* (MSC); Lake County, W of Irons, *Harris 3839, 3851, 3853, 3860, 3864, 3871, 3896* (MSC); Menominee County, N of Cedar River, *Harris 745* (MSC); Montcalm County, Coley Lake, *Harris 1022* (MSC); Shiawassee County, near Laingsburg, *Harris 3743, 3744, 3748, 3749* (MSC); Washtenaw County, NW of Crooked Lake, *Harris 15, 19, 20, 23, 26, 855, 857, 859, 861, 864, 866, 867, 868* (MSC). WISCONSIN: Dane County, Univ. Wis. Arboretum, *Greene,* 23 Oct. 1965 (WIS); Rock County, Lake Koshkonong, *Thomson 1922* (Thomson).

Arthopyrenia sp. 1.

Thallus absent, but brown toruloid hyphae present on the bark surface. Algae not seen.

Ascocarps scattered, brown-black, hemispherical, not immersed, ca. 0.2 mm in diameter. Ascocarp wall brown-black, lacking below, ca. 50 μ thick. Hyphae in bark at base of ascocarp IKI+ purple. Hymenium IKI−. Interthecial hyphae ca. 1 μ thick, somewhat irregular, branched and anastomosed. Asci clavate or clavate-cylindric, only slightly thickened at the tip, 50-60 × 10-15 μ. Spores eight in the ascus, irregularly biseriate, colorless, ovate, ends blunt to pointed, 1-septate, lower cell narrower and usually more pointed than upper, constricted at the septum, without an obvious gelatinous sheath, 12-13.5 × 5-6 μ.

The iodine reaction of the hyphae at the base of the ascocarp is apparently unique in *Arthopyrenia,* although found in *Microthelia wallrothii.*

Illustration: Fig. 19.

Specimen seen: Canada. QUEBEC: Gatineau County, Aylmer, *Macoun,* 6 May 1891 (CAN).

Arthopyrenia sp. 2.

Thallus non-lichenized. Algae not seen.

Ascocarps scattered to crowded, brown-black, hemispherical, ca. one-half immersed, ca. 0.3 mm in diam., 0.15 mm in height. Ascocarp wall brown, lacking below, ca. 50 μ thick. Hymenium IKI−. Interthecial hyphae ca. 1-2 μ thick, filamentous, septate, branched and anastomosed. Asci oblong-elliptic, slightly thickened at the tip, inner wall with a small indentation, 45-55 × 12-13 μ. Spores eight in the ascus, biseriate, colorless, fusiform-elliptical, 1-septate, lower cell slightly narrower than upper, slightly constricted at the septum, with a thin gelatinous sheath, 13-17 × 4-5 μ.

Generally similar to *Arthopyrenia fallax* but with smaller asci and the spores narrower and more pointed. The only collection is on *Fraxinus.*

Illustration: Fig. 20.

Specimen seen: United States. MICHIGAN: Menominee County, N of Cedar River, *Harris 739* (MSC).

Arthopyrenia sp. 3.

Thallus non-lichenized, indicated by a discolored area on bark. No algae seen.

Ascocarps mostly clustered, occasionally fused, rarely scattered, dark brown, dull, hemispherical to subglobose, initially immersed but becoming exposed in age. Ostiole mostly depressed, pale. Ascocarp wall brown, lacking below, consisting mostly of bark cells, 40-75 μ thick. Hymenium IKI−. Interthecial hyphae ca. 1-2 μ thick, filiform, septate, branched and anastomosed. Asci cylindrical to cylindrical-clavate, tip somewhat thickened, inner wall indistinctly indented, 90-120 × 15-18 μ. Spores eight in the ascus, almost uniseriate to biseriate, colorless, becoming pale olive brown in old age, 1-septate, becoming 3-septate with age, cells equal or slightly unequal, with a gelatinous sheath, 20-25 × 6-7.5 μ.

This species is peculiar in its almost uncarbonized ascocarp and in its hymenium which appears opaque white under the dissecting microscope (most appear ± translucent). Although Thomson's exsiccati provide ample material, I hestiate to describe it formally as I am unable to place it in the system satisfactorily. Thomson's collection is on *Gleditsia,* mine on *Tilia.*

Illustration: Fig. 21.

Exsiccati examined: Thoms. Wis. 96 (LD, MICH, MSC, WIS).

Specimens seen: United States. MICHIGAN: Iosco County, Iargo Springs, *Harris 831* (MSC). WISCONSIN: Fond du Lac County, 2 mi N of Rosendale, *Thomson,* 16 May 1947 (LD, MICH, MSC, WIS).

Arthopyrenia sp. 4.

Thallus non-lichenized, not visible. Algae not seen.

Ascocarps scattered, brown-black, hemispherical, superficial, ca. 0.25 mm in diameter, 0.1 mm in height. Ascocarp wall brown-black, lacking below, ca. 25 μ thick. Hymenium IKI−. Interthecial hyphae 1-2 μ thick, filamentous, septate, branched and anastomosed. Asci oblong-elliptical, slightly thickened at the tip, ca. 50-65 × 13 μ. Spores eight in the ascus, biseriate to irregularly arranged, colorless, narrowly ovate, 1-septate, cells unequal, lower cell narrower than the upper, with a gelatinous sheath, 12-17 × 5-6 μ.

This collection is very similar to *Arthopyrenia fallax* (Nyl.) Arn. but has smaller ascocarps and spores. Without further study of the variation in *A. fallax,* I do not wish to make a final disposition. The collection is on *Pinus strobus.*

Illustration: Fig. 22.

Specimen seen: United States. MICHIGAN: Keweenaw County, Isle Royale, Hay Bay, *Lowe 748* (MICH).

EOPYRENULA gen. nov.

Genus Pyrenulacearum affinis *Pyrenulae* sed differt involucrello nullo vel multum reducto, sporis fuscis, transverse septatis, cum endosporio nullo vel forsan leviter evoluto et macroconidiis fuscis, transverse septatis.

Holotype: *Verrucaria leucoplaca* Wallr.

Eopyrenula leucoplaca has long been included in *Pyrenula.* Indeed, it has many characters in common with *Pyrenula:* hymenium and ascus type, colored spores, and curved, filiform, colorless microconidia. It is distinct from *Pyrenula* in lacking a well-developed pseudostromatic involucrellum, in lacking thickened endospore, and in having pycnidia with brown, septate macroconidia. The form of the spores and the presence of macroconidia remind me of *Arthopyrenia faginea.* It is tempting to speculate that *Eopyrenula* represents a link connecting *Pyrenula* and the lichenized members of *Arthopyrenia. Blastodesmia* Massal. is similar in that it has brown, septate spores but its ascocarp, microconidia, and lack of algae seem to place it in the Pleosporaceae.

Eopyrenula leucoplaca (Wallr.) comb. nov.

Verrucaria leucoplaca Wallr., Flora Cryptog. Germ. 3: 299. 1831. *Pyrenula leucoplaca* (Wallr.) Körb., Syst. Lich. Germ. 365. 1855. Type collection not seen.

Pyrenula leucoplaca var. *pluriloculata* Fink, Minnesota Bot. Stud. 2: 709. 1902. Lectotype: Minnesota, Henning, *Fink 357* (MICH). Isolectotype in MIN.

This species was treated by Zahlbruckner (1922) as identical with *Verrucaria farrea* Ach. (*Pyrenula farrea* (Ach.) Branth. & Rostr.), but Vainio

(1921) has examined the type of *V. farrea* and states that it is entirely different.

Thallus endophloeodal, white to pale gray, smooth. *Trentepohlia* abundant, very well-developed, cells 9-12 μ in diameter, forming short chains.

Ascocarps scattered, black to dark brown, shiny or appearing pruinose due to the remains of the covering bark layer, hemispherical to subglobose, ca. 0.3 mm in diameter, usually depressed in the center, initially just under the bark surface but finally one-half to two-thirds exposed. Ascocarp wall entire, brown above, 60-90 μ thick, colorless below, thinner. Hymenium IKI+ dark blue-green becoming orange. Interthecial hyphae ca. 1 μ thick, septate, only rarely branched and anastomosed. Asci cylindric, inner surface lacking a distinct indentation or with a very shallow one formed by a slight thickening of the wall at the tip, 90-100 × 10-12 μ. Spores eight in the ascus, obliquely uniseriate, brown, with the terminal cells somewhat paler, fusiform, 5-6-septate when mature, often slightly constricted at the septa, the central cells largest, decreasing in size toward the ends, lacking a gelatinous sheath, 18-24 × 5-9 μ.

The white thallus, shiny black ascocarp depressed in the center, and brown spores with more than three septa are the diagnostic characters of this species. Its recognition in North America has been complicated by the presence of a non-lichenized fungus found only on the living bark of *Populus tremuloides* (see additional notes, p. 50). This fungus apparently does not occur in Europe, although Vainio (1921) could not find algae associated with *Pyrenula leucoplaca* and on this basis transferred it to *Leptosphaeria.* However, in the small amount of European material I have examined, *Trentepohlia* was abundant, just as in North American material. American collections determined as *Pyrenula leucoplaca* or *P. farrea* seem about evenly divided between *Eopyrenula leucoplaca* and the non-lichenized fungus. The fungus is easily distinguished by its smaller ascocarps, lack of reaction with iodine, and constantly 3-septate spores often with a thick gelatinous outer layer. Fink (1902), believing the European species was constantly 3-septate, unnecessarily described var. *pluriloculata* for specimens with 5-6-septate spores. European material is consistently 5-6-septate, although European authors tend to gloss over the extra septa. The collection in Fink's herbarium designated as the type of this variety is an acceptable lectotype.

While *Eopyrenula leucoplaca* is common in the Great Lakes region, it is apparently rather rare throughout the rest of its range. It grows on *Acer saccharum, Carya, Fraxinus, Populus, Quercus alba, Tilia,* and *Ulmus americana.*

Illustrations: Figs. 23-24; cover. Distribution: Fig. 61.

Exsiccati examined: Cum. I: 194 (CAN, FH, LD, MSC, US, WIS), II: 126 (MICH, MSC); Fl. Hung. 111 (FH); Hepp 957 (FH); Krypt. Vind. 2153 (FH); Macoun II: 227 (CAN, FH, US)[1]; Rel. Far. 453 (MICH, US, WIS); Stenh. 179 (FH, MICH).

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[1]Although Culberson (1959) suggests that Macoun's *Canadian Lichens* should not be treated as exsiccati, I prefer to do so. Sayre (1969) has the later set as the first set and the earlier set as the second set. In order to have a uniform manner of citation, I have adopted Lynge's (1920-1922, 1939) practice, citing the earlier set as Macoun I and the later as Macoun II.

Specimens seen (Great Lakes only): Canada. ONTARIO: Algoma District, Lake Superior Prov. Park, Kenny Lake, *Harris 599-A* (MSC); Carleton County, Ottawa, *Eckfeldt,* 1891-2 (LD), *Macoun,* 16 Apr. 1891 (CAN), 7 May 1892 (CAN), 24 Oct. 1893 (US), Apr. 1896 (FH), 18 Apr. 1896 (CAN, US), 17 Apr. 1902 (CAN, FH, US), 2 May 1903 (FH), 17 Apr. 1905 (FH), 28 Apr. 1905 (FH), 1 May 1907 (FH); Hastings County, Belleville, *Macoun,* Apr. 1870 (CAN), 1874 (FH-Tuck 4027), Central Ontario Junction, *Macoun,* 24 Oct. 1893 (CAN); Nipissing District, Algonquin Prov. Park, Otter Slide Creek, *Macoun,* 19 July 1900 (CAN); Russell County, Navan, *Macoun,* 27 Apr. 1902 (CAN). QUEBEC: Gatineau County, Chelsea, *Macoun,* 15 May 1891 (CAN), 16 May 1891 (US), King's Mountain, Chelsea, *Macoun,* 22 May 1897 (CAN), Hull, *Macoun,* 5 May 1897 (CAN), Aylmer road near Hull, *Macoun,* 30 Mar. 1902 (CAN); Montmorency County, Montmorency, *Macoun,* 1 July 1905 (CAN, MICH, FH), 7 Sept. 1907 (FH).

United States. IOWA: Fayette County, Fayette, *Fink,* 1894 (CAN, US), June 1894 (FH, LD, MICH, MIN, Thomson, US, WIS), July 1894 (FH, LD, MICH, MIN, Thomson, WIS), 17 Aug. 1895 (MICH), 4 Dec. 1895 (CAN, FH, LD, MICH, MSC, US, WIS). MICHIGAN: Cheboygan County, E of Wolverine, *Harris 780* (MSC), Douglas Lake, *Harris 3659* (MSC); Chippewa County, NE of Trout Lake, *Harris 1034* (MSC); Delta County, NE of Rapid River, *Harris 4193* (MSC), NW of Isabella, *Harris 4235, 4252* (MSC); Dickinson County, O'Neil Lake, *Harris 7454* (MSC); Emmet County, S of Levering, *Harris 3634, 3734, 3741* (MSC); Iosco County, Iargo Springs, *Harris 827, 3796* (MSC); Lake County, W of Irons, *Harris 3849, 3854* (MSC); Menominee County, N of Cedar River, *Harris 735, 736, 737, 738, 742, 743* (MSC); Ontonagon County, near Lake of the Clouds, *Harris 674, 676, 677, 685, 690* (MSC). MINNESOTA: County unknown, Flag Island, *Fink 534, 537* (MIN), Minneapolis, *Fink 87* (MIN, US), *153a* (MICH, MIN), Pork Bay, *Fink,* 25 Aug. 1902 (MICH, MIN); Beltrami County, Bemidji, *Fink 555* (MICH, MIN), 597, 676 (MIN), Red Lake, *Fink 1073* (MICH, MIN); Blue Earth County, Mankato, *Fink 31, 207* (MIN); Cook County, Misquah Hills, *Fink 499* (MIN); Koochiching County, Koochiching, *Fink 862, 900* (MIN), *914* (MICH, MIN), Rainy Lake City, *Fink 1147* (MIN); Lake County, Snowbank Lake, *Fink s.n.* (FH, US), *828, 955, 956, 959* (MIN); Lake of the Woods County, Beaudette, *Fink 110, 138* (MIN); Otter Tail County, Battle Lake, *Fink 10* (FH, MIN), *111* (MIN), Henning, *Fink 357* (MICH, MIN); Pennington County, Thief River Falls, *Fink 789* (MICH, MIN), *799* (MIN), *821* (MICH, MIN), *829* (CAN, MIN, US); Roseau County, Warroad, *Fink 200, 209, 229* (MIN); St. Louis County, Auburndale, *Fink,* 6 Sept. 1902 (MICH, MIN), Ely, *Fink 1019* (MIN), Harding, *Fink 1520, 1545, 1591, 1609* (MIN), Kettle Falls, *Fink 1419* (MIN), Tower, *Fink 1796* (MICH, MIN), Vermilion Lake, *Arthur A-89a* (US); Yellow Medicine County, Granite Falls, *Fink s.n.* (MICH), *464, 527, 535, 543* (MIN). NEW YORK: Erie County, Buffalo, *Wilson,* 1871 (FH-Tuck 4027). WISCONSIN: Oconto County, near Hayes, *Culberson 1214* (US); Washburn County, near Long Lake, *Culberson 1739* (LD).

LEPTORHAPHIS Körb.[2]

Syst. Lich. Germ. 371. 1855 nom. cons. (syn. prius *Endophis* Norm., Nyt Mag. Naturvidensk. 7: 240. 1853.). Lectotype (conserved): *Verrucaria oxyspora* Nyl. (= *L. epidermidis* (Ach.) Th. Fr.).

Leptorhaphis is characterized by colorless, acicular to fusiform-cylindrical spores which are arranged in one or two bundles in the ascus. Interthecial hyphae are much branched and anastomosed. Asci are thick-walled and often characteristically truncate. I have never seen any indication of lichenization in any of the species. *Leptorhaphis* is probably best placed in the Pleosporaceae.

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[2]Occasionally spelled without the first "h" as *Leptoraphis,* but the name is conserved with the original spelling.

Leptorhaphis atomaria (Ach.) Szat., Magyar Bot. Lapok 26: 31. 1928.

Lichen atomarius Ach., Lich. Suec. Prodrom. 16. 1798. Lectotype (Vainio, 1921): "Habitat in cortice Fraxini" (H: hb. Ach.).

Many authors (e.g., Keissler, 1938) have placed *Lichen atomarius* Ach. in *Arthopyrenia.* Vainio, however, based his typification on the statement in the original description, "Habitat in cortice Fraxini." Imshaug reports there are two sheets for "*Verrucaria punctiformis* var. *atomaria*" in the Acharian herbarium. Only two collections, one on each sheet, seem to be from Sweden. One, marked "Suecia," on thin smooth bark, which Vainio thought to be *Alnus,* is an *Arthopyrenia.* The other, without locality, on thick, rough bark, which could be *Fraxinus,* bears two species of *Leptorhaphis,* one of which fits Vainio's description. Thus, although Vainio's typification goes against previous usage, it would seem to be correct on the basis of substrate.

Thallus absent. No algae seen.

Ascocarps scattered, dark brown to black, subglobose to hemispherical, initially immersed but very soon almost completely exposed, 0.1-0.2 mm in diameter. Ascocarp wall dark brown, almost entire but usually lacking at the very base, 15-30 μ thick. Hymenium IKI+ orange or occasionally initially pale bluish, rarely IKI−. Interthecial hyphae not distinct, ca. 1 μ thick, much branched and anastomosed with short cells. Asci short clavate, not much thickened at the tip, inner surface mostly not indented, 40-50 × 8-15 μ. Spores eight in the ascus, in one or two bundles, cylindric-fusiform, usually with rounded ends, often curved, 1-3-septate, 20-28 × 2-4 μ.

Leptorhaphis atomaria has not been previously reported from North America. It occurs on *Populus* on both continents. Most North American material is IKI+ orange. Material with this reaction has been recognized as a separate variety in Europe but this seems unwarranted. The only other North American specimens seen are from Massachusetts and Arizona.

Illustrations: Fig. 25; Swinscow, 1965, Fig. 4.

Exsiccati examined: Magn. 126 (FH); Rab. 147 (MICH).

Specimens seen (Great Lakes only): Canada. ONTARIO: Algoma District, Agawa Bay, *Harris 583* (MSC); Thunder Bay District, 1 mi E of Lake Marie Louise, *Erbisch 426* (MSC), Rossport, *Brodo 6372* (CAN).

United States. IOWA: Allamakee County, Effigy Mounds, *Imshaug 27906* (MSC); Delaware County, Backbone St. Park, *Imshaug 28011* (MSC). MICHIGAN: Alger County, Kingston Lake, *Harris 660* (MSC); Emmet County, Wilderness St. Park, *Harris 810* (MSC); Iosco County, Corsair St. Forest Campground, *Harris 820* (MSC); Iron County, S of Kenton, *Harris 721* (MSC); Keweenaw County, Isle Royale, Forbes Lake, *Wetmore 4142* (MSC), Hay Bay, *Lowe 752* (MICH, US); Ontonagon County, Lake of the Clouds, *Harris 680* (MSC).

Leptorhaphis contorta Degel., Ark. Bot. 30A(1): 13. 1942.

Type collection: Maine, Prince's Point near Brunswick, Arcadia Inn, on *Quercus borealis* in mixed woods, *Degelius,* 3 Sept. 1939. Isotype in US.

Thallus non-lichenized, not visible or indicated only by a lighter area on the bark. Algae not seen.

Ascocarps scattered, black, occasionally quite shiny, subglobose to hemispherical, 0.1-0.2 mm in diameter. Ascocarp wall lacking below, dark brown, 15-25 μ thick. Hymenium IKI−. Interthecial hyphae ca. 1.5 μ thick,

with short cells, branched and anastomosed. Asci cylindrical, not much thickened at the tip, 50-65 × 10-12 μ (45-54 × 10.5-13 μ in Degelius 1942a). Spores eight in the ascus, in a single bundle, acicular, 1-(3)-septate, 35-50 × 2-3 μ.

The type collection is on *Quercus,* but most of the rest of the material examined is on *Populus* and differs slightly in having larger, more rounded and emergent ascocarps. Degelius (1942b) reported this species from North Carolina on *Prunus* but the duplicate seen (US) is *L. parameca. Leptorhaphis contorta* is distinguished by its long spores and lack of reaction with iodine. It may not be distinct from *L. parameca.* It is quite common in the northern part of the Great Lakes.

Illustration: Fig. 26.

Specimens seen: Canada. ONTARIO: Algoma District, Agawa Bay, *Harris 582* (MSC); Thunder Bay District, Rossport, *Brodo 6372* (CAN), 22 mi W of White River, *Brodo 6685* (CAN).

United States: MAINE: Sagadahoc County, Prince's Point near Brunswick, *Degelius,* 3 Sept. 1939 (US). MASSACHUSETTS: Bristol County, New Bedford, *Willey* (FH-Tuck 3989, US); Norfolk County, Weymouth, *Willey* (FH-Tuck 3990, US). MICHIGAN: Cheboygan County, E of Wolverine, *Harris 787* (MSC); Chippewa County, NE of Trout Lake, *Harris 1042, 1076* (MSC); Dickinson County, O'Neil Lake, *Harris 7474, 7543* (MSC); Iron County, S of Kenton, *Harris 716, 719* (MSC); Keweenaw County, Isle Royale, McCargo Cove, *Lowe 441* (MICH); Menominee County, N of Cedar River, *Harris 752* (MSC); Otsego County, Grass Lake, *Harris,* 10 Oct. 1962 (MSC). WISCONSIN: Vilas County, near Trout Lake, *Culberson 1584* (WIS).

Leptorhaphis epidermidis (Ach.) Th. Fr., Lich. Arct. 273. 1860.

Lichen epidermidis Ach., Lich. Suec. Prodr. 16. 1798. Lectotype: BM-Ach. coll. 281-282(2). Isolectotype in PC (Hue).

Lichen epidermidis Ach. is the basionym for both *Leptorhaphis epidermidis* (Ach.) Th. Fr. and *Arthopyrenia epidermidis* (Ach.) Massal. (Ricerch. Auton. Lich. 167. 1852). Zahlbruckner (1921) erroneously attributed the basionym *Verrucaria epidermidis* DC. to Massalongo's species. The first to realize that Acharius and others had included several taxa in *V. epidermidis* was Nylander (1852). He retained the name *V. epidermidis* for what is now an *Arthopyrenia* and gave a new name to the *Leptorhaphis, Verrucaria oxyspora.* Both Massalongo and Körber in the original publications of *Arthopyrenia* and *Leptorhaphis* accepted Nylander's treatment. In 1860 Th. Fries arbitrarily reversed Nylander, and used *epidermidis* in *Leptorhaphis* and treated Nylander's *Arthopyrenia* as *A. analepta.* Zahlbruckner, unfortunately I think, accepted Th. Fries' treatment rather than the earlier ones by Nylander, Massalongo, and Körber. Vainio (1921) examined the Acharian herbarium in Helsinki and stated that the type collection of *Verrucaria (Lichen) epidermidis* was mixed, neither part containing spores. Imshaug reports there are three pieces of bark on the *Verrucaria epidermidis* sheet in the Acharian herbarium. One may be eliminated as it is labeled "β. albissima" and consists only of pycnidia. The other two are apparently sterile as Vainio said. Peter James very kindly has supplied crush mounts from three of the four pieces of bark in the Acharian material of *V. epidermidis* in the British Museum. "β. albissima" [281-282(3)] consists of pycnidia with large, acicular conidia just as the

material in Helsinki. A second [281-282(1)] is a *Polyblastiopsis*. The third [281-282(2)] is identical with the current concept of *Leptorhaphis epidermidis*. In view of the nomenclatural history of the epithet *epidermidis*, I would personally prefer to accept the priority of Nylander's treatment. However, since *Leptorhaphis epidermidis* is a well known and generally accepted name and can be lectotypified in the accepted sense, it seems best to do so and preserve the name. Also, the fact that Acharian material in two herbaria is the *Leptorhaphis* argue for this disposition.

Thallus non-lichenized, not visible. No algae seen.

Ascocarps scattered, black, dull to slightly shiny, hemispherical or slightly flattened, ca. 0.2 mm in diameter, surrounded by an elliptical ring of dark hyphae ca. 0.1 mm wide. Ascocarp wall lacking below, dark brown, 20-30 μ thick. Hymenium IKI−. Interthecial hyphae ca. 1-2 μ thick, with short cells, branched and anastomosed. Asci short clavate to oblong, often truncate, not much thickened at the tip, inner surface sometimes with a shallow indentation, 32-45 × 10-15 μ. Spores eight in the ascus, mostly in a single bundle, colorless, cylindrical-acicular, often with one or both ends sharply pointed, usually curved or twisted, 1(-3)-septate, not constricted at the septum, 20-30 × 2-4 μ.

Leptorhaphis epidermidis is a widespread circumboreal species, rare south of the Hemlock–White Pine–Northern Hardwoods region. It occurs on *Betula papyrifera* and *B. populifolia*.

Illustrations: Figs. 27-28; Swinscow, 1965, Fig. 3; Vězda, 1968, Fig. 9. Distribution: Fig. 62.

Exsiccati examined: Hepp 460 (FH); Krypt. Vind. 1353 (FH, US); Malbr. 100 (MSC); Norrl. 389 (MSC); Thoms. Wis. 41 (CAN, MICH, Thomson, US, WIS).

Specimens seen (Great Lakes only): Canada. ONTARIO: Algoma District, Lake Superior Prov. Park, Sand River, *Imshaug 26214* (MSC); Russell County, 3 mi E of Cumberland, *Brodo 9598* (CAN); Simcoe County, Devil's Glen, *Imshaug 26925* (MSC); Thunder Bay District, 15 mi W of Marathon, *Brodo 6513* (CAN), Nipigon, *Brodo 6198* (MSC).

United States: ILLINOIS: Cook County, *Calkins,* 1900 (FH). MICHIGAN: Alger County, Kingston Lake, *Harris 626, 663* (MSC); Charlevoix County, Beaver Island, *Imshaug 27479* (MSC); Cheboygan County, Vincent Lake, *Engel 1191* (MSC), *Harris 3624* (MSC); Chippewa County, Bay View U.S. Forest Campground, *Harris 1117* (MSC), NE of Trout Lake, *Harris 1033, 1077, 1144, 1146* (MSC); Clare County, N of Harrison, *Harris 954* (MSC); Iosco County, Iargo Springs, *Harris 4025* (MSC); Keweenaw County, Lake Medora, *Thomson 3301* (Thomson, WIS), Isle Royale, Rock Harbor, *Lowe 575* (FH, MICH); Montcalm County, Coley Lake, *Harris 1025* (MSC); Ontonagon County, near Lake of the Clouds, *Harris 673, 678, 686, 688, 689, 691* (MSC). MINNESOTA: Beltrami County, Bemidji, *Fink 608* (MIN), *671* (MICH); Blue Earth County, Mankato, *Fink 140* (MICH); Koochiching County, Emo, *Fink 724* (MIN), Rainy Lake City, *Fink 1113* (MIN); Lake County, Beaver Bay, *Fink 697* (MICH, MIN); Lake of the Woods County, Warroad, *Fink 154, 193, 204* (MIN); Otter Tail County, Henning, *Fink 189* (MICH, MIN); St. Louis County, Duluth, *Kimball,* 1900 (US), Harding, *Fink 1522* (MIN), Kettle Falls, *Fink 1492* (MIN), Tower, *Fink 1789* (MIN). NEW YORK: Erie County, Buffalo, *Clinton,* 1876 (US). WISCONSIN: Bayfield County, Cornucopia, *Brodo 5810* (CAN); Douglas County, Brule River Valley, *Thomson*, 9 Aug. 1946 (CAN, MICH, Thomson, US, WIS).

Leptorhaphis parameca (Massal.) Körb., Parerg. Lich. 386. 1856.

Sagedia parameca Massal., Symmict. Lich. 97. 1855. Type collection not seen.

Description modified from Keissler (1938). Thallus non-lichenized, not visible. No algae seen.

Ascocarps scattered or clustered and occasionally fused, dark brown, flattened, circular or elliptical in outline, 0.15-0.2 mm in diameter, surrounded by a dark hyphal ring (poorly developed in Great Lakes material). Ascocarp wall lacking below, dark brown, ca. 25-30 μ thick. Hymenium IKI+ bluish. Interthecial hyphae with short cells, branched and anastomosed. Asci clavate, slightly thickened at the tip, 30-50 x 7-10 μ. Spores eight in the ascus, in a single bundle, colorless, acicular, with several indistinct septa, 30-50 x 2.5-3 μ.

This European species has not been reported previously from North America. American material seems to agree closely with European specimens. The distinguishing features are the long spores and the hymenial reaction with iodine. It occurs mainly on *Prunus*, also on *Betula papyrifera* and *B. lutea.*

Illustration: Fig. 26.

Specimens seen: United States. MASSACHUSETTS: Norfolk County, Weymouth, *Willey* (FH-Tuck 3990, US). MICHIGAN: Alger County, Kingston Lake, *Harris 623, 624*(MSC); Cheboygan County, Vincent Lake, *Harris 3623* (MSC); Clare County, N of Harrison, *Harris 948* (MSC); Roscommon County, Backus Lake Flooding, *Imshaug 25491* (MSC). NEW HAMPSHIRE: County unknown, near Mt. Pleasant House, *Willey*, 1889 (US). NORTH CAROLINA: Swain County, Mt. Kephart, *Degelius,* 15 Sept. 1939 (US). TENNESSEE: Sevier County, near Mt. Le Conte, *Imshaug 38496* (MSC).

MICROTHELIA Körb.

Syst. Lich. Germ. 372. 1855. Lectotype (Müller & von Arx, 1962): "*M. biformis* (Leight.) Massal." (= *M. micula* Körb.).

The status, both nomenclatural and biological, of the genus *Microthelia* has been somewhat confused. It was erected by Körber as a lichen genus. Rehm (1879) and Saccardo (1882) tentatively considered it to be synonymous with *Didymosphaeria* Fuck. (1869), a non-lichenized genus. Although Saccardo included *Microthelia* within *Didymosphaeria*, he made no new combinations, possibly since *Microthelia* as the older genus would have replaced *Didymosphaeria.* Currently both genera are regarded as distinct non-lichenized genera (Müller & von Arx, 1962). Vainio (1921) divided *Microthelia* into two genera, *Microthelia*, saxicolous and lichenized, and *Didymosphaeria*, corticolous and non-lichenized. However, *Microthelia* has been typified, both through usage and lectotypification, by *M. micula*, a corticolous non-lichenized species. Thus, Vainio's *Didymosphaeria* should bear the name *Microthelia.* This leaves the saxicolous lichen genus without a name if one wishes to recognize it as distinct. In this treatment the only species considered are those referable to *Microthelia* as accepted by lichenologists as well as modern mycologists. There is a great need for close study of this group to define both generic and specific limits.

Microthelia is recognized by its relatively small, brown, 1-septate spores

and superficial, conical or hemispherical pseudothecia. Müller & von Arx include it in the Pleosporaceae.

Microthelia micula Körb.

Syst. Lich. Germ. 373. 1855. Type collection not seen.

Microthelia micula may be illegitimate. Although Körber makes no mention of *Verrucaria biformis* Borr. in the synonymy, he has the following statement in his discussion. "Ich sehe nichts "Zweigestaltiges" an dieser Flechte, weshalb ich den (ohnediess anderweitig vielfach gebrauchten) Borrer'schen Speciesnamen '*biformis*' nicht annahm." Thus one may wish to treat Körber's name as a superfluous new name for *Verrucaria biformis* Borr. (= *Arthopyrenia biformis*). Müller & von Arx (1962) use *Microthelia biformis* (Leight.) Massal. for this species. However, if one treats *Verrucaria biformis* Leight. as distinct from *V. biformis* Borr. it is a later homonym. *Microthelia biformis* Massal. (1856) is probably acceptable, but I have not seen the publication. Zahlbruckner (1922) cites *Verrucaria lyellii* Leight. (1851) and *V. cinerella* Nyl. (1855) as synonyms of *Microthelia micula.* Since I have not seen the types of these species, nor Massalongo's publication, I have retained the name *Microthelia micula.*

Thallus non-lichenized, indistinct or indicated by a gray discoloration on the bark. No algae seen.

Ascocarps scattered to clustered, black, dull, hemispherical, 0.2-0.3 mm in diameter. Ascocarp wall lacking below, occasionally almost entire, brownish-black, 50-60 μ thick. Hymenium IKI+ bluish or IKI−. Interthecial hyphae 1-2 μ thick, septate, branched and anastomosed. Asci cylindrical to slightly obclavate, tip somewhat thickened, inner surface indistinctly indented. Spores eight in the ascus, biseriate to irregularly arranged, brown, ovate, 1-septate, constricted at the septum, cells usually slightly unequal, 12-30 × 5-12 μ.

According to Scheinpflug (1958), the spores in *Microthelia micula* are equal-celled and unequal in *M. applanata* (Fr.) Müller, an otherwise very similar species. All of the collections which I have examined vary in this respect within the same ascocarp. The difficulty is that all characters used so far to separate collections seem to vary independently. There seems to be a group with smaller spores, mostly under 22 × 10 μ, but overlap occurs with a second group with spores mostly 22-30 × 10-12 μ. The majority of collections have the spore wall minutely ornamented but a few have a smooth wall. Some collections have spores with a gelatinous outer layer, others do not. According to Vainio (1921) the hymenium is IKI−, while Keissler (1938) found it to be IKI+ bluish. Degelius (1942b) comments he has found *M. micula* to be both IKI+ and IKI−. About 75% of the Great Lakes region specimens are IKI+ bluish. There is also great variation in the completeness of the ascocarp wall.

Illustrations: Fig. 30; Vězda, 1968, Fig. 12.

Exsiccati examined: Hepp 108 (FH).

Specimens seen (Great Lakes only): Canada. ONTARIO: Algoma District, Lake Superior Prov. Park, ½ mi N of Doc Grieg Lake, *Harris 556, 561, 562, 563, 564, 565, 566, 580* (MSC).

United States: MICHIGAN: Alger County, Kingston Lake, *Harris 612, 616, 617, 650, 651, 659, 666* (MSC); Charlevoix County, Beaver Island, *Imshaug 27573* (MSC);

Cheboygan County, E of Wolverine, *Harris 781, 802* (MSC); Clare County, N of Harrison, *Harris 941* (MSC); Emmet County, Wilderness St. Park, *Harris 807* (MSC); Ingham County, East Lansing, *Harris 55, 56, 63, 71* (MSC); Iosco County, Silver Valley St. Forest Campground, *Harris 817, 820* (MSC); Iron County, Teepee Lake, *Harris 695* (MSC); Isabella County, N of Mt. Pleasant, *Imshaug 21082* (MSC); Kalamazoo County, Kellogg Forest N of Augusta, *Harris 273, 320, 321, 322, 323, 325, 413* (MSC); Keweenaw County, Isle Royale, Siskowit Lake, *Lowe 643, 689* (MICH); Mackinac County, Mackinac Is., *Imshaug 27270-C*(MSC); Menominee County, N of Cedar River, *Harris 750* (MSC); Ontonagon County, near Lake of the Clouds, *Harris 679, 683, 684, 692* (MSC); Washtenaw County, Crooked Lake, *Harris 2* (MSC). MINNESOTA: Blue Earth County, Mankato, *Fink 88, 129* (MICH); Pennington County, Thief River Falls, *Fink 798* (MICH, MIN); Yellow Medicine County, Granite Falls, *Fink 513* (MICH, MIN).

Microthelia wallrothii (Hepp) Rehm, Hedwigia 18: 163. 1879.

Pyrenula wallrothii Hepp, Flecht. Eur. 709. 1860. Type collection: An Birkenrinde, bei Zürich, *Hegetschweiler.* Isotypes in FH, FH-Tuck 4066.

Description modified from Keissler (1938). Thallus non-lichenized, not visible. No algae seen.

Ascocarps scattered, black, often slightly shiny, hemispherical to flattened hemispherical, often depressed in the center, surrounded by a well-developed dark, elliptical hyphal ring, which may be up to 0.15 mm wide. Ascocarp wall entire, brown-black, thinner below and rarely lacking in the center. Hyphae at base of ascocarp IKI+ pale violet. Hymenium IKI−. Interthecial hyphae 1.5-2 μ thick, septate, branched and anastomosed. Asci clavate, tip somewhat thickened, inner surface not indented, 40-50 × 14-18 μ. Spores eight in the ascus, biseriate, brown, oblong, 1-septate, not constricted at the septum, 10-17 × 6-7 μ.

Microthelia wallrothii is unusual in that some of the hyphae at the base of the ascocarp and, perhaps, in the hyphal ring turn pale violet in IKI. This reaction has been noted rarely in some collections of *Arthopyrenia*, *Leptorhaphis*, and *Polyblastiopsis*, but it appears to be a constant character of *M. wallrothii.* Both American and European specimens are variable in regard to the thickness of the basal part of the ascocarp wall, and it may even be lacking below. *Microthelia oblongata* Müll. Arg., described from material collected in Massachusetts by Willey, is very similar but lacks any violet reaction with IKI.

The majority of collections of *Microthelia wallrothii* come from Iowa and the Black Hills (Wetmore, 1968). It reaches the Great Lakes region only in northern Minnesota and Iowa and is apparently restricted to *Betula papyrifera.*

Illustration: Fig. 31.

Exsiccati examined: Hepp 709 (FH, FH-Tuck 4066).

Specimens seen (Great Lakes only): United States. IOWA: Fayette County, Fayette, *Fink,* June 1894 (MICH, Thomson, WIS), 19 Aug. 1895 (MICH, Thomson, US), Apr. 1898 (MICH, US). MINNESOTA: Beltrami County, Red Lake, *Fink 1036* (MIN); Cook County, Grand Marais, *Fink*, 28 July 1902 (US), Grand Portage, *Fink 56* (MICH). NEW YORK: Rockland County, Palisades, *Austin 649* (FH-Tuck 3990).

MYCOGLAENA v. Höhn.

Sitzungsber. Kaiserl. Akad. Wiss. Math.-Naturwiss. Cl. Abt. 1.188: 1210. 1909. Holotype: *Verrucaria subcoerulescens* Nyl.

Riedl (1971) has made a comparative anatomical study of *Mycoglaena, Polyblastiopsis,* and *Microglaena.* He concludes that there is a continuum with *Mycoglaena* at one end and *Microglaena* at the other. Anatomically he finds there is very little difference between *Mycoglaena* and *Polyblastiopsis,* primarily the absence or presence of a gelatinous sheath on the spores. However, he includes *Polyblastiopsis fallaciosa* in *Mycoglaena.* In my opinion this species is a typical *Polyblastiopsis* (see p. 39). If it is removed from *Mycoglaena,* one may distinguish the two genera in a rather simplistic fashion. The ascocarp wall in *Mycoglaena* is green, often quite a bright green, often with bluish tints, and is KOH- but HNO_3 reddish. The ascocarp wall in *Polyblastiopsis* is brownish, blackish, or olivaceous, especially around the ostiole and is olivaceous in KOH but HNO_3-. *Mycoglaena* can also be characterized by the shape of the asci, which tend to be more cylindrical and truncate at the tip than in *Polyblastiopsis* and by less abundant and less branched interthecial hyphae, in addition to the lack of a gelatinous spore sheath. If one accepts this definition of *Mycoglaena,* the species included form a homogeneous, easily recognized group. In fact, they form an almost unbroken continuum from the 3-septate *M. myricae* through *M. quercicola* to *M. meridionalis* which has submuriform spores, then through larger and more subdivided spores until *M. subcoerulescens* (Nyl.) v. Höhn. and *M. acuminans* (Nyl.) Vain. are reached. I have seen no material of *M. lichenoides* (Rehm) Riedl and *M. viridis* (Rehm) Riedl and, therefore, cannot say whether they belong in *Mycoglaena* as circumscribed here.

Mycoglaena meridionalis (Zahlbr.) Szat. in Degen, Fl. Velebitica 3: 310. 1938.

Polyblastiopsis meridionalis Zahlbr., Ann. Naturhist. Hofmus. 23: 223. 1909. Type collection: Krypt. Vind. 1646, Hungaria: ad ramulos *Fraxini ornus* in valle "Skurinjatal" prope Fiume, *Schuler.* Isotypes in FH & US.

Lamb (1963) gives Szatala as the transferring author, but I have not seen the original. If for some reason it should turn out to be invalid, Riedl (1971) has also made the combination.

Arthopyrenia cinerescens Massal. (1855) as represented in Massal. Lich. exs. Ital. 43 (FH-Tuck 4084) is this species, but since I am not certain whether this is the type collection or if there is additional material in Massalongo's herbarium, I do not wish to make a new combination.

Thallus non-lichenized, indicated by pale gray area on the bark. No algae seen.

Ascocarps scattered, bluish- or greenish-black, circular to elliptical in outline, flattened, often sunken in the center, 0.4-0.6 mm in diameter. Ascocarp wall green, greenish-brown or greenish-black, HNO_3 + reddish, lacking below, 10-25 μ thick. Hymenium IKI-. Interthecial hyphae not abundant, ca. 1-2 μ thick, septate, branched and anastomosed. Asci cylindrical, usually with truncate tip, not thickened at the tip, variable in length

depending on the distance from the ostiole, 75-130 x 15-20 μ. Spores eight in the ascus, uniseriate to biseriate, colorless, submuriform, oblong or oblong-elliptic, with 3-5(6) transverse septa, 1-5 cells with 1-(2) longitudinal septa, constricted at the septa, especially the median one, without a gelatinous sheath, 18-26 x (7)8-10 μ (20-23 x 7.5-9 μ in the type collection).

Mycoglaena meridionalis is characterized by green ascocarps and submuriform spores. It has not been recognized previously from North America, although all of the specimens are from old herbarium material. It is apparently widely distributed in eastern North America and grows on the smooth bark of *Acer rubrum, Myrica, Prunus,* and *Quercus.*

Illustrations: Fig. 32.

Exsiccati examined: Krypt. Vind. 1646 (FH, US); Merr. II: 93 (MICH, MSC).

Specimens seen: United States. ILLINOIS: Menard County, *Hall,* 1878 (MICH). IOWA: Black Hawk County, La Porte, *Peck,* 21 Feb. 1896 (MICH). MASSACHUSETTS: Bristol County, New Bedford, *Willey,* 1885 (US). MAINE: Oxford County, S. Hartford, *Parlin 13451* (Thomson). MISSOURI: Saline County, near Emma, *Demetrio 40* (MICH). NEW JERSEY: Gloucester County, Newfield, *Ellis 22* (US). NEW YORK: Saratoga County, E. Galway, sine coll. (FH); Suffolk County, Orient, *Latham* (FH, MICH); Washington County, Greenwich, *Fitch,* 1865-66 (US). OHIO: Ashtabula County, Orwell, *Bogue,* 1899 (MICH, MSC).

Mycoglaena myricae (Nyl.) comb. nov.

Verrucaria myricae Nyl., Flora 52: 297. 1869. *Arthopyrenia myricae* (Nyl.) Zahlbr., Ann. Naturhist. Hofmus. 18: 365. 1903. Holotype: Brest, ad *Myrica, Crouan,* 1868 (H: Nyl. hb. 799).

Verrucaria epidermidis var. *aeruginella* Nyl., Not. Sällsk. Fauna Fl. Fenn. Förh. 8: 173. 1866. *Verrucaria aeruginella* Nyl., Flora 55: 365. 1872. *Arthopyrenia aeruginella* (Nyl.) Arn., Flora 68: 162. 1885. Holotype: Kola, *Fellman,* 1863 (H: Nyl. hb. 800).

Description modified from Keissler (1938). Thallus non-lichenized, indicated by a paler grayish or brownish area on the bark. No algae seen.

Ascocarps scattered, greenish-black, elliptic, flattened, 0.2-0.5 mm long by 0.1-0.3 mm wide, ca. 0.1 mm high. Ascocarp wall green to greenish-brown or greenish-black, HNO_3 + reddish, containing bark cells, 25-35 μ thick. Hymenium IKI−. Interthecial hyphae ca. 1-2 μ thick, septate, branched and anastomosed. Asci cylindrical, slightly thickened at the tip, inner surface occasionally indistinctly indented, 50-75 x 10-15 μ. Spores eight in the ascus, subbiseriate, hyaline, fusiform, usually with sharply pointed ends, 3-septate, often with one of the median cells enlarged, constricted at the septa, lacking a gelatinous sheath, 18-23 x 6-8 μ.

Nylander combined *Verrucaria myricae* with *V. epidermidis* var. *aeruginella* and used the name *V. aeruginella.* However, *V. myricae* has priority at the species level. The type collection of *V. myricae,* from France, has somewhat larger and more flattened ascocarps (0.3-0.5 mm in diam.) than the type collection of *V. aeruginella,* from Finland (0.2-0.4 mm in diam.). The spores in the former are smaller (16-20 x 5-7.5 μ; Nyl. 17-22 x 6-7 μ) than in the latter [17-23(27) x 6-8 μ; Nyl. 18-23 x 7-9 μ]. Other Scandinavian and American collections are intermediate in spore size or closer in spore size to

V. myricae. Mycoglaena myricae is distinguished by green ascocarps and 3-septate pointed spores. Probably not rare, but seldom collected due to its inconspicuousness and unusual substrate.

Illustration: Fig. 33.

Exsiccati examined: Krypt. Vind. 861 (FH), 3477 (US); Magn. 127 (FH); Mig. 100 (MICH, MSC); Zw. 1197 (MICH).

Specimens seen: United States. MICHIGAN: Alger County, Kingston Lake, *Harris 6033, 6034* (MSC); Dickinson County, O'Neil Lake, *Harris 7652* (MSC); Keweenaw County, Isle Royale, Rock Harbor, *Lowe 567* (MICH).

Mycoglaena quercicola sp. nov.

Differt a *Mycoglaenae meridionali* sporis 3-5-septatis, raro loculo unico cum septo longitudinali et a *M. myricae* sporis apicibus rotundatis, saepe plus quam 3-septatis.

Holotype: Iowa, Bremer Co., *Fink,* 1895, as *Pyrenula punctiformis* (US). Isotypes in CAN & US.

Thallus non-lichenized, indicated by a lighter area on the bark. Algae not seen.

Ascocarps scattered, greenish-black, circular to elliptical, flattened, often sunken in the center, 0.6 mm in diam. or ca. 0.6 mm in length and 0.1-0.2 mm less in width, 0.12-0.15 mm in height. Ascocarp wall green, HNO_3 + reddish, lacking below, 20-25 μ thick. Hymenium IKI−. Interthecial hyphae often sparse, ca. 1-2 μ thick, filamentous, septate, branched and anastomosed. Asci cylindric with truncate tip, thick walled, not much thickened at tip, inner surface not indented, length variable depending on distance from ostiole, 70-125 × 12-18 μ. Spores eight in the ascus, subbiseriate, colorless, oblong, elliptic or fusiform, 3-5 transversely septate, rarely with a single cell septate, constricted at the septa, without a gelatinous sheath, 18-30 × (5)6-8(9) μ, (24-30 × 6-8 μ, 3-5 transversely septate in type).

Pycnidia ca. 0.1 mm, greenish. Microconidia short rods, 4-6 × 1 μ.

Mycoglaena quercicola seems intermediate between *M. myricae* and *M. meridionalis.* The ascocarp is very similar to that of *M. meridionalis,* which also occurs on *Quercus,* but differs in that only 2 of 79 spores from 14 specimens are submuriform and then only a single cell is septate, while *M. meridionalis* has submuriform spores with several cells septate. *Mycoglaena myricae* differs in substrate preference and has pointed spores, which are uniformly 3-septate with one of the median cells enlarged. *Mycoglaena quercicola* has spores with more rounded ends and more-or-less equal cells.

Mycoglaena quercicola is always on smooth, young bark of *Quercus.*

Illustration: Fig. 34.

Exsiccati examined: Cum. I: 249 (CAN, MICH, MSC, US, WIS), II: 189 (FH-Riddle, LD, MICH, MSC, US).

Specimens examined. United States. ILLINOIS: Fulton County, Canton, *Wolf* (US). IOWA: Bremer County, *Fink,* 1895 (CAN, US), Aug. 1895 (FH, MICH, US); Fayette County, *Fink,* 1894 (FH, LD, MICH, MIN, WIS), 27 July 1894 (CAN, FH-Riddle, LD, MICH, MSC, US, WIS). MINNESOTA: County unknown, Minneapolis, *Fink 188* (MIN, US). OHIO: Franklin County, Georgesville, *Bogue* (FH).

MYCOPORELLUM Müll. Arg.

Rev. Mycol. (Toulouse) 6: 14. 1884. Lectotype (Riedl, 1962): *Mycoporellum sparsellum* (Nyl.) Müll. Arg.

Mycoporellum, like *Mycoporum,* has multichambered ascocarps. It differs in having colorless, 1-septate spores. None of the species I have examined seem to be lichenized. Riedl (1962) places it in the Mycoporaceae but I would include it in the Pleosporaceae.

Mycoporellum sp.

Thallus absent. No algae seen.

Ascocarps scattered, brown, elliptical, flattened, up to 0.5 × 0.3 mm, containing 10-20 chambers separated by ± uncarbonized sterile tissue, each chamber with its own ostiole. Carbonized upper layer 20-40 μ thick. Hymenium IKI−. Interthecial hyphae thick, septate and branched, appearing parenchymatous. Asci obclavate with a short, thick stipe, thickened at the tip, 55-65 × 18-20 μ. Spores fusiform-elliptical, 1-septate, septum slightly eccentric with lower cell slightly longer and narrower, with a gelatinous sheath, 20-26 × 5-7 μ.

The hymenium, asci, and spores are much like *Arthopyrenia punctiformis* but the multi-chambered ascocarp easily distinguishes the two taxa.

Both collections are apparently on *Quercus.*

Illustration: Fig. 35.

Specimens seen: United States. IOWA: Bremer County, *Fink,* Aug. 1895 (MICH). MINNESOTA: Blue Earth County, Mankato, *Fink 90* (MIN).

MYCOPORUM Flot. ex Nyl.

Mém. Soc. Sci. Nat. Cherbourg 3: 186. 1855. (non Meyer, 1825). Holotype: *Mycoporum flotowianum* (Koerb.) comb. nov.[3]

Dermatina auct. non (Almq.) Zahlbr.: Zahlbr., Cat. Lich. Univ. 1: 547. 1922.

Zahlbruckner (1922) raised *Mycoporum* subg. *Dermatina* Almq. to generic level without comment. However, the five species originally included in *Dermatina* are placed by Zahlbruckner in either *Arthonia* or *Arthothelium.* Thus *Dermatina* is a synonym of *Arthonia* or *Arthothelium,* depending on which of the original species is selected as the type.

Nylander was the first to validly publish *Mycoporum* in the sense which was used from 1855 till 1922. Since *Mycoporum* Nyl. is a later homonym of *Mycoporum* Meyer, the genus requires a new name unless *Mycoporum* Nyl. is conserved. I believe that conservation would produce the least upset and would require very few new combinations. Unfortunately, one of them is the type species. Nylander based the genus on "*Lecidea elabens* Schaer.," a misidentification by Schaerer of *Lecidea elabens* Fries. Körber (1865) cor-

[3]Basionym: *Arthothelium flotowianum* Körb., Parerg. Lich. 261. 1865 *ut nom. nov. pro Lecidea elabens* Schaer., Lich. Helv. Spicil. 199. 1833. Lectotype: Schaer. Lich. Helv. exs. 232, circa Wachseldorn (FH-Tuck 2907).

rectly supplied a new epithet. Although there has been no doubt that Schaerer's exsiccatus is the type collection of the species, no lectotype has previously been formally designated.

Mycorporum has been closely allied to *Cyrtidula* Minks, but Minks (1876, 1891) excluded *Mycoporum elabens* (= *M. flotowianum*) from *Cyrtidula.* This would preclude the use of *Cyrtidula* to replace *Mycoporum* unless further studies reveal that Minks was incorrect. The task is complicated by the fact that 17 species were included in the original publication of *Cyrtidula,* without designation of a type.

Mycoporum is characterized by ascocarps with more than one multiascal chamber, each chamber with its own ostiole, and by brown, muriform spores. The type species and *Mycoporum pycnocarpum* both have a thallus with sparse to abundant *Trentepohlia.* The genus seems to be ascolocular. Zahlbruckner (1903) made *Mycoporum* the type genus for a new family, the Mycoporaceae, based on the multi-loculate ascocarp. Riedl (1962) has emended this family to consist predominantly of genera with unilocular ascocarps such as *Arthopyrenia.* This would seem to be reasonable, but I can see no valid reasons for maintaining such a family distinct from the Pleosporaceae.

Mycoporum pycnocarpum Nyl., Flora 41: 38. 1858 (as *pyrenocarpum*). Mém. Soc. Sci. Nat. Cherbourg 5: 135. 1857 nom. nud.

Dermatina pyrenocarpa (Nyl.) Zahlbr., Cat. Lich. Univ. 1: 550. 1922. Holotype: Mexico, Sierra de Cristóbal, *Fr. Müller,* 1855, (H: Nyl hb. 4223). Isotype? in MICH.

Mycoporum pycnocarpum var. *ohiense* Nyl., Mém. Soc. Sci. Nat. Cherbourg 5: 135. 1857 nom. nud. *Mycoporum ohiense* Nyl. ex Fink, Lichen Flora of the U.S. 67. 1935. *Dermatina ohiensis* (Nyl. ex Fink) Zahlbr., Cat. Lich. Univ. 10: 108. 1938. Lectotype: Ohio, *Lea* (ex hb. Hooker) (H: Nyl. hb. 4234).

Although Zahlbruckner chose to use *pyrenocarpa,* it is clear that this spelling must be a printing error in the original description. The year before its valid publication Nylander had used *pycnocarpum* in a list, the type collection bears this spelling and the three times Nylander referred to this species after 1858 he consistently used *pycnocarpum.*

While Nylander apparently never felt *Mycoporum pycnocarpum* var. *ohiense* was worthy of description, Fink validated the name at the species level. Since Fink clearly credited the name to Nylander, the type should be from Nylander's material. The two collections under this name in Nylander's herbarium are typical *M. pycnocarpum.* I have chosen the Lea collection as the lectotype since the other would not have suggested the epithet *ohiense.* Fink's concept of *M. ohiense* was based on a specimen in Tuckerman's herbarium (FH-Tuck 3733) from New York collected by E. C. Howe and determined by Tuckerman as *M. pycnocarpum* v. *ohiense.* Several fragments have clearly been removed from this collection. A comparison of Fink's and Tuckerman's herbarium notes is most revealing. Fink hb. 12,925, marked co-type, has the note "spores 8, 94 to 126 by 23 to 30 μ, oblong-ellipsoid,

cells 8 to 12 by 2 to 4, size of spores makes it a species!!!!." Tuckerman notes "Th. oblongae $\frac{94\text{-}126}{23\text{-}30}$ micr." Fink, or whomever Fink communicated with at the Farlow Herbarium, clearly misread Th. (ecae) as Sp.(orae). The spore size was given by Tuckerman as 23-43 x 9-16 μ, normal for *M. pycnocarpum.* Thus Fink's extraordinary spore size, on which basis he recognized *M. ohiense,* is actually the ascus size. This error was somewhat further compounded when recorded in Fink's Flora as 94-120 x 23-30 μ.

Thallus endophloeodal, indicated by a lighter area on the bark. *Trentepohlia* present in scattered clumps, not abundant.

Ascocarps scattered, dark brown to black, often slightly shiny, cushion-shaped, elliptical in outline, 0.2-1.0 mm in length, usually 0.1-0.2 mm less in width, containing 1-10 separate chambers. Ostioles large, usually easily visible due to their lighter color. Upper layer of stroma dark, carbonaceous, ca. 20-40 μ thick, carbonization usually not penetrating very far downward into the sterile layers separating the chambers, which are mostly hyaline, ca. 10-20 μ thick, stromatic layer at the base hyaline or somewhat carbonaceous, especially below the layers separating the chambers. Hymenium IKI−. Interthecial hyphae not distinct, short-celled, much branched and anastomosed, appearing almost parenchymatous. Asci obclavate-saccate, much thickened at the tip, 70-85 x 35-50 μ. Spores eight in the ascus, irregularly arranged, initially hyaline but soon brown, oblong, muriform with 7-9(11) transverse septa and 1-3 longitudinal septa, constricted only at the median septum dividing the spores into two usually unequal parts, 30-48(51) x (12)15-18(21) μ.

Mycoporum pycnocarpum is the only common Great Lakes region representative of a group of three genera which have more than one chamber in the ascocarp. Care must be taken to avoid confusion with members of the Arthoniaceae, where single asci are randomly scattered through an irregular or discoid stroma. Under a dissecting microscope, *Mycoporum* and its relatives, when wetted, show obvious ostioles for each chamber. Such openings are never present in the Arthoniaceae. The multichambered nature of *Mycoporum* is usually clear, and the ascocarp resembles a group of small black beads glued together. In addition the asci and hymenium in the Arthoniaceae react either bluish or reddish with IKI while *Mycoporum* does not react.

Mycoporum pycnocarpum occurs from the Great Lakes and Maine south to Florida and Mexico. Fink (1935) reports it from California but the only specimen in his herbarium from California is an *Arthothelium.* It has been most commonly collected on *Acer rubrum,* but also on *Alnus, Betula, Carpinus, Crataegus, Fagus, Quercus,* and *Tilia.*

Illustrations: Figs. 36-37. Distribution: Fig. 63.

Exsiccati examined: Cum. I: 286 (MSC), II: 218 (FH, FH-Riddle, MICH, MSC); Lojk. Univ. 150 (MICH); Macoun I: 179 (CAN, MSC), II: 199 (FH, CAN, MICH, MSC).

Specimens seen (Great Lakes only): Canada. ONTARIO: Hastings County, Central Ontario Junction, *Macoun,* 22 Oct. 1893 (CAN, FH, MICH, MSC), Madoc, *Macoun,* 24 Oct. 1893 (FH, CAN, MSC). QUEBEC: Gatineau County, Aylmer, *Macoun,* 6 May 1891 (CAN).

United States. MICHIGAN: Alger County, Shingleton, *Hinds,* 27 July 1968 (MICH); Cheboygan County, Douglas Lake, *Nichols,* 1923 (FH, MICH, UMBS); Clare County, N of Long Lake, *Harris 3974* (MSC). NEW YORK: County unknown, Western New York, *Sartwell,* 1852 (FH-Tuck 3733), *Wilson,* 1884 (FH-Tuck 3735); Erie County, Buffalo, sine coll. (FH); Essex County, Jay, *Riddle 442* (FH-Riddle). OHIO: Defiance County, Defiance, *Fullmer,* 1894 (FH).

PLAGIOCARPA gen. nov.

Genus Pyrenulacearum similis *Pyrenulae* quoad structuram basicam ascocarpi sed differt ostiolo laterali vel saltem eccentrico, collum eminentem saepe formanti, apicis ascorum cum cavitate cruciformi et sporis hyalinis vel atrobrunneis, transverse septatis, cum endosporio leviter vel forsan non evoluto.

Holotype: *Plagiocarpa septemseptata* R. C. Harris.

Plagiocarpa shares a number of important characters with *Pyrenula.* The ascocarp consists of a pseudostromatic involucrellum from which the exciple becomes separated except around the ostiole. In *Pyrenula* the ostiole is vertical and does not form a projecting neck. The ostiole in *Plagiocarpa* is often completely lateral, normally eccentric, and only very rarely vertical. It normally forms a neck which occasionally may be longer than the body of the ascocarp. The length and eccentricity of the neck seem to depend on the depth and orientation of the ascocarp initial. The hymenium of all species of *Plagiocarpa* is IKI+ bluish becoming orangish and is heavily inspersed with oil droplets. These hymenial characters are found in some species of *Pyrenula,* e.g., *P. neglecta.* The interthecial hyphae are mostly unbranched, as in *Pyrenula.* The asci are unique, as far as I know, in respect to the peculiarly shaped indentation in the inner surface of the ascus tip (Fig. 41). The spores differ from those of *Pyrenula* in lacking any massive development of the endospore. The brown-spored species have better developed endospore than the colorless-spored *Plagiocarpa hyalospora.* In *P. septemseptata* and *P. macrospora* I have found pycnidia with colorless, filiform microconidia very similar to those of *Pyrenula.* The phycobiont is *Trentepohlia.* This has been verified by culture for one collection of *P. hyalospora.*

I have chosen *P. septemseptata* as the type species since three of the four species are brown-spored. Although *P. hyalospora* has colorless spores, it is obviously closely related to the brown-spored species by ascus and ascocarp structure. The genus seems a homogeneous and easily recognizable group. While it seems closely related to *Pyrenula,* it also seems related to *Lithothelium. Lithothelium cubanum* Müll. Arg. and *Plagiocarpa hyalospora* are almost identical in hymenium and spore type. *Lithothelium* differs in having several ascocarps fused into a unit and in having asci of the *Pyrenula* type. Degelius (1942b), noting the lateral ostiole, described *Plagiocarpa hyalospora* as a *Pleurotrema. Pleurotrema* differs in having an *Arthopyrenia* type ascocarp rather than *Pyrenula* type.

Plagiocarpa hyalospora (Nyl.) comb. nov.

Verrucaria hyalospora Nyl., Mém. Soc. Acad. Maine Loire 4: 48. 1858., Mém. Soc. Sci. Nat. Cherbourg 5: 337. 1857. nom. nud. *Arthopyrenia*

hyalospora (Nyl.) Fink, Lich. Flora U.S. 50. 1935. Holotype: In Nova Anglia (H: Nyl. hb. 1251).

Pleurotrema solivagum Degel., Ark. Bot. 30A(3): 21. 1942. Type collection: Tennessee, Great Smoky Mountains, Cherokee Orchard, on *Tsuga canadensis* in deciduous forest, 760 m, *Degelius,* 11 Sept. 1939. Isotype in US.

Thallus endophloeodal, pale gray or whitish, smooth. *Trentepohlia* usually abundant and well-developed, forming short chains.

Ascocarps scattered, dark brown, not shiny, subglobose, initially completely immersed in the bark but commonly almost completely superficial in age, 0.5-0.6 mm in diameter. Ostiole mostly displaced to one side of the ascocarp, not vertical, forming a short projecting neck, rarely almost vertical and not projecting. Involucrellum entire, dark brown, containing bark cells, ca. 80 μ thick above, thinner below, 20-40 μ. Exciple thin, ca. 10-20 μ, pale brown to almost colorless, usually free from the involucrellum except at the ostiole, often shrinking away from the involucrellum upon drying. Hymenium IKI+ greenish-blue (becoming red-orange if the iodine concentration is high enough), heavily inspersed with small oil drops. Interthecial hyphae ca. 1 μ thick, septate, very rarely branched and apparently not anastomosed. Asci cylindric or somewhat obclavate, thickened at the tip, inner wall indentation often cross-shaped in optical section, 65-90 x 20 μ. Spores eight in the ascus, roughly biseriate to irregularly arranged, colorless, oval, 3-septate, not constricted at the septa, endospore slightly thickened, lumina subspherical to almost cylindrical, without a gelatinous sheath, 18-27(30) x 7-10(12) μ.

Plagiocarpa hyalospora is easily recognized by its eccentric ostiole and colorless spores with slightly thickened endospore. It is one of the most common pyrenolichens in the Great Lakes region. It ranges east to New England and south to North Carolina. It most commonly grows on *Acer saccharum, Fraxinus, Tilia americana,* and *Betula lutea,* less commonly on *Ulmus, Carya, Liquidambar,* and *Quercus.* Degelius reported the type collection of *Pleurotrema solivagum* as being on *Tsuga,* but the isotype seen was clearly on *Acer.*

Illustration: Fig. 38. Distribution: Fig. 64.

Exsiccati examined: Lojk. Univ. 200 (LD, MICH, US); Merr. I: 102 (FH, FH-Riddle, MICH, US).

Specimens seen (Great Lakes only): Canada. ONTARIO: Carleton County, Carp, *Macoun,* 16 Oct. 1907 (CAN, FH), Ottawa, *Eckfeldt,* 1891-2 (LD), *Macoun,* 18 Apr. 1896 (US), 20 Apr. 1905 (FH); Hastings County, Belleville, *Macoun,* Apr. 1871 (CAN), 1874 (FH-Tuck 4026), Central Ontario Junction, *Macoun,* 22 Oct. 1893 (CAN), 24 Oct. 1893 (CAN); Lanark County, Carleton Place, *James M. Macoun,* 12 May 1892 (CAN); Middlesex County, London, *Drummond 38,* (FH-Tuck 4026); Nipissing District, Algonquin Prov. Park, *Imshaug 26879* (MSC), *Macoun,* 7 June 1900 (CAN), 19 July 1900 (CAN), Lake Timagami, *Cain 21643* (LD, US); Parry Sound District, near Magnetawan, *Plitt,* 29 July 1920 (US); York County, Nashville, *Cain 25310* (US). QUEBEC: Chelsea, *Macoun,* 17 May 1907 (CAN).

United States. MICHIGAN: Alger County, Kingston Lake, *Harris 618, 667* (MSC); Berrien County, Warren Woods, *Harris 216-A, 217* (MSC); Cheboygan County, Douglas Lake, Gorge, *Harris 3657, 3661* (MSC), *Nichols,* 1923 (MICH, UMBS), *Robinson & Crum,* 5 Aug. 1958 (UMBS); Chippewa County, NE of Trout Lake, *Harris 1043-B* (MSC); Clare County, N of Long Lake, *Harris 3769, 3772, 3775, 3907-A, 3912, 3928, 3932,*

3959, 3960, 3967, 3972, 3973, 3975 (MSC); Delta County, NE of Isabella, *Harris 4185* (MSC), NW of Isabella, *Harris 4230-B, 4234, 4241-B, 4251* (MSC); NE of Rapid River, *Harris 4208* (MSC); Dickinson County, NNW of Ralph, *Harris 7593, 7599, 7602, 7603* (MSC); Ingham County, Mich. State University, *Harris 84, 910* (MSC); Iosco County, Iargo Springs, *Harris 829, 836, 837, 838, 840, 841, 842, 843, 3801, 3813, 4004, 4008* (MSC); Iron County, near Teepee Lake, *Harris 694, 696, 727, 728, 730-A* (MSC); Lake County, W of Irons, *Harris 3843, 3845, 3847, 3858, 3898, 3899* (MSC); Luce County, Upper Tahquamenon Falls, *Harris 1129-A, 1135* (MSC). NEW YORK: Chautauqua County, Chautauqua, *Green,* 2 Aug. 1898 (FH); Genesee County, Bergen Swamp, *Muenscher & Brown 910* (MICH); Niagara County, Goat Island, sine coll. (FH-Tuck 4026); Otsego County, Richfield Springs, *Willey,* 1884 (US). WISCONSIN: Sawyer County, Flambeau River St. Forest, *Hale 2037* (WIS).

Plagiocarpa macrospora sp. nov.

Plagiocarpa sporis atrobrunneis, 7-septatis, magnis, 60-80 x 21-26 μ.

Holotype: Virginia, Madison County, Stony Man, *Imshaug 38564* (MSC).

Thallus endophloeodal, pale gray, smooth. *Trentepohlia* present.

Ascocarps scattered, dark brown, subglobose, initially immersed but finally ca. one-half exposed, 0.5-0.8 mm in diameter. Ostiole lateral or eccentric, often forming a short neck up to 0.2 mm in length. Involucrellum entire, brown, 50-100 μ thick. Exciple brownish, thin, indistinct, often pulling away from the involucrellum. Hymenium IKI+ blue-green becoming orangish. Interthecial hyphae ca. 1-2 μ, septate, not obviously branched and anastomosed. Asci subcylindrical to obclavate, slightly thickened at the tip, inner surface with a cross-shaped indentation, 180-220 x 50-60 μ. Spores initially eight in the ascus, occasionally 1-4 spores not developing, subbiseriate to irregularly arranged, dark brown, 7-septate, cells largest in the center decreasing in size toward the ends, not constricted at the septa, without a gelatinous sheath, 55-80 x 20-26 μ.

Pycnidia ca. 0.1 mm in diameter, brown. Microconidia colorless, filiform, 12-18 x 1 μ.

Plagiocarpa macrospora, the rarest species of the genus, is immediately recognizable by its very large spores. The Virginia collections are on *Quercus alba,* the Michigan one on *Ulmus,* and the Ontario one is indicated as *Alnus* on the label but is clearly on *Fraxinus.*

Illustration: Fig. 39.

Specimens seen: Canada. ONTARIO: Carleton County, Ottawa, *Macoun,* 30 Apr. 1897 (CAN).

United States: MICHIGAN: Clare County, N of Long Lake, *Harris 3927-B* (MSC). VIRGINIA: Madison County, Stony Man, *Imshaug 38564, 38583* (MSC).

Plagiocarpa phaeospora sp. nov.

Plagiocarpa sporis atrobrunneis, 3-septatis, 30-40 x 12-16 μ.

Holotype: Tennessee, Wilson County, Cedars of Lebanon State Park, *Harris 1279-A* (MSC). Isotypes in B, BM, Harris, TNS, UPS, & US.

Thallus endophloeodal, grayish, smooth. *Trentepohlia* abundant.

Ascocarps scattered, dark brown, flask-shaped to subglobose, initially completely immersed but often almost completely superficial in age, 0.6-0.7 mm in length (without neck), 0.5-0.6(0.7) mm in width. Ostiole usually forming a lateral neck which may be up to 0.6 mm long. Involu-

crellum entire, brown, containing bark cells, 50-100 μ thick, inner below. Exciple brownish, thin, ca. 25 μ thick, often separating from the involucrellum. Hymenium IKI+ blue-green becoming orangish, heavily inspersed with oil droplets. Interthecial hyphae ca. 1-2 μ thick, septate, not obviously branched and anastomosed. Asci subcylindrical, slightly thickened at the tip, inner surface with a cross-shaped indentation, 125-150 x 25-35 μ. Spores eight in the ascus, biseriate to irregularly arranged, dark brown, 3-septate with the end cells one-fourth to one-sixth as large as the median cells, not constricted at the septa, without a gelatinous sheath, 30-40(45) x (12)14-16(18) μ.

Plagiocarpa phaeospora is characterized by its dark brown, 3-septate spores with very small end cells. It is uncommon (but in one case locally abundant) in the Great Lakes region. The type and the majority of the collections are on *Fraxinus*, less often on *Ulmus*.

Illustrations: Fig. 40-41.

Specimens seen: Canada. ONTARIO: Carleton County, Carp, *Macoun*, 16 Oct. 1907 (FH); Hastings County, Shannonville, *Macoun*, 1882 (CAN).

United States. MICHIGAN: Alger County, Au Train Falls, *Harris 3709* (MSC), Au Train Lake, *Smith 2103* (MICH); Clare County, N of Long Lake, *Harris 3771, 3927-A, 3936-A, 5902* (MSC); Delta County, NW of Isabella, *Harris 4240* (MSC); Emmet County, S of Levering, *Harris 3739-B* (MSC); Iosco County, Iargo Springs, *Harris 832-B* (MSC). TENNESSEE: Wilson County, Cedars of Lebanon St. Park, *Harris 1279-A* (B, BM, Harris, MSC, TNS, UPS, US). WISCONSIN: Vernon County, Wild Cat Mtn. St. Park, *Thomson 12817* (WIS).

Plagiocarpa septemseptata sp. nov.

Plagiocarpa sporis atrobrunneis, 7-septatis, 34-45 x 12-15 μ.

Holotype: North Carolina, Transylvania County, Pisgah National Forest, White Pines Campground, *Harris 3373* (MSC). Isotypes in B, BM, CAN, HEL, Harris, TNS, UPS, & US.

Thallus endophloeodal, grayish or not visible, smooth. *Trentepohlia* abundant.

Ascocarps scattered, dark brown, flask-shaped to subglobose, initially completely immersed but becoming more-or-less superficial with age, 0.5-0.9 mm in length (without neck), usually ca. 0.1 mm less in width. Ostiole eccentric to lateral, often forming a neck up to 0.35 mm in length. Involucrellum entire, brown, containing bark cells, 75-120 μ thick, thinner below. Exciple brownish, thin, indistinct, often separating from the involucrellum. Hymenium IKI+ blue-green becoming orangish, inspersed with oil droplets. Asci obclavate to subcylindrical, thickened at the tip, inner wall indentation cross-shaped in optical section, 100-140 x 30-40 μ. Spores eight in the ascus, subbiseriate to irregularly arranged, dark brown, 7-septate, median cells largest, decreasing in size toward the ends, not constricted at the septa, without gelatinous sheath, 30-42(45) x 12-15 μ.

Pycnidia brown, ca. 0.1 mm in diameter. Microconidia colorless, filiform, 12-28 x 1 μ.

Plagiocarpa septemseptata differs from *P. macrospora*, which also has dark brown 7-septate spores, in having spores about half as large. It is almost as widely distributed as *P. hyalospora* but less commonly collected. It is

locally abundant in Michigan and most commonly grows on *Fraxinus* but occasionally on *Acer saccharum, Quercus, Thuja,* and *Ulmus.*

Illustrations: Figs. 42-44.

Specimens seen: Canada. ONTARIO: Carleton County, Carp, *Macoun,* 16 Oct. 1907 (FH), Ottawa, *Eckfeldt,* 1891-2 (LD), *Macoun,* 20 Apr. 1905 (FH); Hastings County, Shannonville, *Macoun,* 1882 (CAN); Lanark County, Carleton Place, *James M. Macoun,* 12 May 1892 (CAN, FH).

United States. KENTUCKY: McCreary County, Daniel Boone Nat. Forest, Sawyer Campground, *Harris 1186-A, 1197-A* (MSC). MAINE: Knox County, Rockland, *Merrill,* 15 Aug. 1909 (CAN). MARYLAND: Baltimore County, Catonsville, *Plitt,* 14 Jan. 1911 (FH, MICH). MICHIGAN: Alger County, Au Train Lake, *Smith 2103* (MICH); Berrien County, Warren Woods, *Harris 219-B* (MSC); Cass County, Russ Forest 7 mi S of Decatur, *Harris 5879-C* (MSC); Clare County, N of Long Lake, *Harris 3764, 3766, 3771, 3936-B, 3956, 3966, 3971, 7663* (MSC); Delta County, NW of Isabella, *Harris 4257* (MSC); Emmet County, S of Levering, *Harris 3739, 3740* (MSC); Ingham County, Mich. State University Campus, *Harris 47, 87* (MSC); Iosco County, Iargo Springs, *Harris 832* (MSC); Menominee County, N of Cedar River, *Harris 733* (MSC). NEW YORK: Chautauqua County, Chautauqua, *Green,* 2 Aug. 1898 (FH). NORTH CAROLINA: Transylvania County, Pisgah Nat. Forest, Moore Cove, *Harris 3245* (MSC), White Pines Campground, *Harris 3373* (B, BM, H, Harris, MSC, TNS, UPS, US). VIRGINIA: Madison County, Stony Man, *Imshaug 38591* (MSC).

POLYBLASTIOPSIS Zahlbr.

In Engler & Prantl, Natürl. Pflanzenfam. 1(1*): 65. 1903. Lectotype (Clements, 1909): *Verrucaria naegelii* Hepp.

Polyblastiopsis is essentially a new name for *Polyblastia* Müll. Arg. (1882, non Lönnr. 1852). In his circumscription Müller included thirteen species. Although Clements did not justify his lectotype it seems to be acceptable.

Polyblastiopsis can be characterized by colorless, submuriform to muriform spores with a well-developed gelatinous sheath, by abundant, richly branched and anastomosed filiform interthecial hyphae, and by brownish, blackish or somewhat olivaceous ascocarp wall. For the distinction between *Polyblastiopsis* and *Mycoglaena* see p. 28. The genus clearly belongs in the Pleosporaceae.

Morgan-Jones and Swinscow (1965) include *Polyblastiopsis sericea* (Massal.) Zahlbr. in *Microglaena.* Since *P. sericea* seems to be a typical *Polyblastiopsis,* this implies that they would treat the genus as a synonym of the older genus, *Microglaena.* I prefer, at this time, to recognize both genera, the primary distinction being that *Microglaena* always has a well-developed lichenized thallus while *Polyblastiopsis* is apparently non-lichenized. I have not tried to evaluate this problem further except to note that *Microglaena,* as presently circumscribed, seems to be heterogeneous. *Microglaena sphinctrinoides* (Nyl.) Lönnr. and *M. corrosa* (Körb.) Arn. have asci with apical apparatus stained deep blue with iodine. However, the asci of the type species, *M. modesta* (Nyl.) A. L. Sm., do not react with iodine and are rather similar to those of *Polyblastiopsis.*

Polyblastiopsis fallaciosa (Stizenb. ex Arn.) Zahlbr. in Engler & Prantl, Natürl. Pflanzenfam. 1(1*): 65. 1903.

Polyblastia fallaciosa Stizenb. ex Arn., Flora 46: 604. 1863. Type collection: Arn. Lich. exs. 269, An birkenrinde bei Eichstätt, *Arnold,* Oct. 1863. Isotype in BM.

Verrucaria frankliniana Leight., Jour. Linn. Soc., Bot. 9: 199, pl. 2, f. 2-3. 1867. Lectotype: River St. Mary's, Lake Superior. (BM).[4]

Polyblastiopsis quercicola Brodo, New York State Mus. & Sci. Serv. Bull. 410: 147, f. 82-83. 1968. Holotype: New York, Suffolk County, Shoreham, *Brodo 2651* (MSC). Isotype in CAN.

Polyblastiopsis fallaciosa has been the victim of some misunderstandings. Arnold used the name "*Arthopyrenia punctiformis fallax,*" (based on *Verrucaria epidermidis* v. *fallax* Nyl., which is an *Arthopyrenia*) for collections of this species before the spores were examined. When Arnold (1863) learned that the spores were muriform he corrected his misidentifications by describing *Polyblastia fallaciosa.* American workers, apparently unaware of or not understanding Arnold's correction, continued to perpetuate the original error, not realizing the epithet *fallax* belonged to an *Arthopyrenia.* As a result, American herbarium material under the combinations *Pyrenula punctiformis* v. *fallax, Polyblastiopsis fallax,* and *Arthopyrenia fallax* is a mixture of *Polyblastiopsis fallaciosa* and *Arthopyrenia* spp. *Polyblastiopsis fallaciosa* is treated by Fink (1935) as both *P. fallaciosa* and *P. fallax.*

Riedl (1971) has placed *P. fallaciosa* in *Mycoglaena.* My examination of the type has led me to conclude that *P. fallaciosa* is not congeneric with *Mycoglaena.* Although *Polyblastiopsis fallaciosa* often has an olive-green color around the ostiole, the ascocarp wall is basically brown, HNO_3- and often olive-green in KOH. The asocarp wall of *Mycoglaena,* in the sense which I accept it, is some shade of blue-green, HNO_3+ reddish and KOH-. *Polyblastiopsis fallaciosa* would also seem to be excluded from *Mycoglaena sensu* Riedl since the ascocarp structure seems to be identical with *Polyblastiospsis lactea* and the spores have a well-developed gelatinous sheath.

Thallus non-lichenized, light gray to whitish or not visible when on *Betula.* Algae not seen.

Ascocarps scattered, black, sometimes shiny, hemispherical, especially when young, but in age flat-topped or even depressed in the center, 0.2-0.3 mm in diameter, when on *Betula* surrounded by an elliptical ring of dark hyphae. Ascocarp wall entire or lacking below, brown, often olive-greenish around the ostiole, colorless and thinner below. Hymenium IKI-. Interthecial hyphae 1.5-2 μ thick, with short cells, much branched and anastomosed, occasionally appearing almost parenchymatous. Asci clavate to cylindrical, inner surface of thickened tip with or without an indentation, 50-105 x 15-25 μ. Spores initially eight in the ascus, 1-2(4) commonly not developing but their remnants usually visible in the ascus, irregularly arranged, colorless, oblong to elliptic, submuriform with 5-7 transverse septa and 1-2

[4]There are two pieces of bark in the packet from Leighton's herbarium. The lower piece bears typical *P. fallaciosa.* The upper has only immature ascocarps. Therefore, the lower piece has been selected as the lectotype.

longitudinal septa, usually constricted at the septa, more constricted at the median septum, one-half of the spore sometimes broader than the other, with a thick gelatinous sheath, 17-25 x 7-10 μ.

Pycnidia black, 50-100 μ in diameter. Microconidia colorless, simple, rod-shaped, 8-10 x 1-1.5 μ.

Brodo (1968) described *Polyblastiopsis quercicola* on the basis of slightly larger spores and having hyaline, non-septate conidia. The type collection of *P. fallaciosa* has microconidia identical with those found in *P. quercicola.* Neither Riedl (1971) nor I have found the brown, septate macroconidia attributed to *P. fallaciosa*. They are probably associated with some other fungus since *Polyblastiopsis* should have colorless macroconidia (Orton, 1915). The aspects of *P. fallaciosa* when it grows on *Quercus, Betula,* and *Acer* are somewhat different, but I have not been able to find any consistent, correlated morphological differences. I prefer to retain them all under *P. fallaciosa.* The type of *Verrucaria frankliniana* appears to be on *Acer.*

Verified specimens of *Polyblastiopsis fallaciosa* come from South Carolina to Maine and west to Minnesota and Iowa. The only European specimen I have seen is the type. *Polyblastiopsis fallaciosa* is most often found on *Betula papyrifera, Acer saccharum* (esp. when young), and *Quercus alba*; more rarely on *Fraxinus, Juglans,* and *Ulmus.*

Illustrations: Figs. 45-46. Distribution: Fig. 65.

Exsiccati examined: Arn. 269 (BM).

Specimens seen (Great Lakes only): Canada. ONTARIO: Algoma District, NW of Batchawana, *Imshaug 25959-A* (MSC), Lake Superior Prov. Park, Kenny Lake, *Harris 600* (MSC), Sand River, *Imshaug 26269* (MSC); Carleton County, Ottawa, *Macoun,* 5 Jan. 1907 (FH); Frontenac County, Eastview Park, *Brodo 9664* (MSC); Simcoe County, Devil's Glen, *Imshaug 26943, 26971, 26997* (MSC). QUEBEC: Gatineau County, Eardley, near Ramsey Lake, *Brodo 9583* (CAN), Kirk's Ferry, *Brodo 9634* (CAN).

United States. ILLINOIS: Cook County, *Calkins* (Thomson). IOWA: Fayette County, Fayette, *Fink,* June 1894 (MICH, WIS), 19 Aug. 1895 (MICH, Thomson, US), Apr. 1898 (CAN, FH, LD, MICH, MSC, MIN, US), 1 mi E of Wadena, *Wetmore 13578* (MSC); Hardin County, Steamboat Rock, *Wetmore 15426* (CAN); Jackson County, Maquoketa Caves Park, *Imshaug 28081* (MSC). MICHIGAN: Alger County, E of Munising, *Harris 3712* (MSC), Kingston Lake, *Harris 628* (MSC); Allegan County, W of Allegan, *Harris 400, 401* (MSC); Berrien County, Warren Woods, *Harris 213, 218* (MSC); Charlevoix County, Beaver Island, *Imshaug 27478, 27568* (MSC); Cheboygan County, Douglas Lake, Gorge, *Harris 3618* (MSC), Grapevine Point, *Chamberlin,* 6 Aug. 1960 (UMBS), E of Wolverine, *Harris 775, 776, 777, 778, 782* (MSC); Chippewa County, Lake Munuscong, *Harris 1099, 1103* (MSC), Whitefish Bay, *Dewart,* 20 Aug. 1891 (FH); Clare County, N of Harrison, *Harris 947, 950* (MSC); Clinton County, W of Grand Ledge, *Harris 3754, 3758, 3759* (MSC); Delta County, Chicago Lake, *Harris 4268* (MSC); Dickinson County, NNW of Ralph, *Harris 7598, 7608* (MSC); Emmet County, near Middle Village, *Hinds,* 23 July 1966 (UMBS), W of Mackinaw City, *Imshaug 25869* (MSC), W of Pellston, *Engel 1063, 1066* (MSC), *Harris 3706, 3707* (MSC), Wilderness State Park, *Imshaug 27358* (MSC); Ingham County, Mich. State University Campus, *Harris 911, 916* (MSC); Iosco County, Iargo Springs, *Harris 830, 833, 835* (MSC); Iron County, S of Kenton, *Harris 717* (MSC); Kalamazoo County, Kellogg Forest N of Augusta, *Harris 140, 316, 417, 512* (MSC); Keweenaw County, Fort Wilkins, *Thomson 2998* (Thomson, WIS), N of Fort Wilkins, *Thomson 3006* (Thomson, WIS); Lake County, W of Irons, *Harris 3838* (MSC); Mackinac County, Mackinac Island, *Imshaug 27270-B, 27273, 27289* (MSC); Menominee County, N of Cedar River, *Harris 740, 748, 755, 756* (MSC);

Ontonagon County, near Lake of the Clouds, *Harris 671, 672* (MSC); Presque Isle County, Clinton Lake, *Harris 3700* (MSC); Washtenaw County, NW of Crooked Lake, *Harris 1, 6, 8, 10, 858, 860, 863, 865* (MSC). MINNESOTA: Beltrami County, Bemidji, *Fink 601, 624* (MIN), *670* (MICH, MIN); Blue Earth County, Mankato, *Fink 66* (MIN); Cook County, Grand Marais, *Fink,* 28 July 1902 (FH, US), 12 Aug. 1902 (MICH), Grand Portage, *Fink,* 12 Aug. 1902 (MIN), Grand Portage Is., *Fink 85* (MICH, US), Gunflint, *Fink 276* (MIN, US), Misquah Hills, *Fink 503* (MICH); Koochiching County, Emo, *Fink 690* (MIN), Koochiching, *Fink 898* (MIN), Rainy Lake City, *Fink 1178* (MIN); Lake County, Snowbank Lake, *Fink 871, 950* (MIN); Lake of the Woods County, Beaudette, *Fink 81, 89* (MIN); Otter Tail County, Henning, *Fink 170, 353* (MIN). WISCONSIN: Bayfield County, Cornucopia, *Brodo 5804* (CAN); Oneida County, near Big Stone Lake, *Culberson 1604* (WIS).

Polyblastiopsis lactea (Massal.) Zahlbr., Natürl. Pflanzenfam. 1(1*): 65. 1903.

Blastodesmia lactea Massal., Ricerch. Auton. Lich. 181. 1852.

Thallus non-lichenized, indicated by a gray to whitish patch on the bark. Algae not found.

Ascocarps scattered, black, slightly shiny, hemispherical to conical, initially immersed but finally superficial in age, 0.3-0.4 mm in diameter, surrounded by a dark hyphal ring. Ascocarp wall entire, brown, thicker above, ca. 50 μ, thinner below, 15-20 μ. Hymenium IKI−. Interthecial hyphae ca. 1-2 μ thick, septate, branched and anastomosed. Asci cylindrical to clavate, tip little thicker than the walls, inner surface with a broadly rounded indentation. Spores four in the ascus, occasionally fewer, irregularly arranged, colorless, oblong to broadly elliptical, muriform with 6-8 transverse septa and 2-3 longitudinal septa, slightly constricted at the septa, especially the median one, thick gelatinous sheath evident in KOH, (27)30-36(39) x 12-15 μ.

Polyblastiopsis lactea, apparently, is the only species in the genus with four spores to the ascus. All others are initially two- or eight-spored. *Polyblastiopsis fallaciosa,* initially with eight spores, has a strong tendency for spore abortion. It is commonly found with six to seven and rarely with as few as four mature spores in the ascus. This, for the most part, accounts for the majority of the previous records of *P. lactea* in North America. The spores of *P. fallaciosa* are smaller and if asci with fewer than eight spores are examined carefully, the remains of the undeveloped spores can be found. Massalongo (1852) allowed up to six spores in the ascus in this species, but only a single European collection has shown more than four spores initially.

Only a single collection of *P. lactea* is known from the Great Lakes region. It was apparently common in New England at the time Willey was collecting. The Great Lakes collection is on *Fraxinus*; elsewhere on a variety of substrates.

Illustrations: Fig. 47; Vězda, 1968, Fig. 36.

Exsiccati examined: Arn. 564 (FH); Kbr. 381 (US).

Specimens seen: United States. ILLINOIS: Fulton County, Canton, *Wolf* (US). MAINE: Knox County, Owls Head, *Merrill,* 29 May 1921 (FH), Rockport, *Merrill,* 2 May 1912 (FH). MASSACHUSETTS: Bristol County, New Bedford, *Willey* (FH-Tuck 4041, 4042, 4043, US); Essex County, Salem, sine coll., (US); Norfolk County, Weymouth, *Willey* (US). MICHIGAN: Emmet County, Wilderness State Park, *Harris 816* (MSC).

Polyblastiopsis sp. 1.

Thallus lacking. No algae seen.

Ascocarps scattered, brown to blackish, small, 0.15-0.20 mm in diameter. Ascocarp wall lacking below, 20-30 μ thick. Hymenium IKI−. Interthecial hyphae thick, septate and much branched with an almost parenchymatous appearance. Asci oval to obovate, wall thickened at the tip, 35-45 × 18-30 μ. Spores eight in the ascus, irregularly arranged, hyaline, ovate-elliptic to clavate, 3-5 transverse septa, 1-2(4) cells septate, with a gelatinous sheath, 17-19 × 6-7.5 μ.

This species differs from *Polyblastiopsis fallaciosa* in ascocarp, ascus, and spore size and in ascus and spore shape. It is very similar to some specimens from northern Europe, but I have found no name for it.

I have seen only three collections from North America. The one from Minnesota is apparently on *Quercus,* the two from South Dakota are on *Betula.*

Illustrations: Figs. 48-49, Vězda, 1968, Fig. 15 (as *P. fallaciosa*).

Specimens seen: United States. MINNESOTA: Blue Earth County, Mankato, *Fink 94* (MIN). SOUTH DAKOTA: Custer County, 6 mi NNE of Custer, *Wetmore 10055* (MSC); Lawrence County, town of Whitewood, *Wetmore 11126* (MSC).

Polyblastipsis sp. 2.

Thallus absent. No algae seen.

Ascocarps scattered, brownish-black, hemispherical or slightly flattened, not much immersed, ca. 0.25 mm in diameter. Ascocarp wall lacking below, 20-30 μ thick. Hymenium IKI−. Interthecial hyphae 2-3 μ thick, septate, branched and anastomosed. Asci obclavate to obovate, thickened at the tip, 65-75 × 25-30 μ. Spores eight in the ascus, irregularly arranged, clavate with the upper part considerable shorter and broader than the lower, 5 transverse septa with 1-4 cells septate, with a gelatinous sheath, 25-30 × 7.5-10 μ.

Differs from *Polyblastiopsis fallaciosa* in size of ascocarp and shape of asci and spores.

The only known collection is on *Alnus.*

Illustrations: Figs. 50-51.

Specimen seen: Canada. ONTARIO: Carleton County, Ottawa, *Macoun,* 30 Apr. 1897 (CAN).

PYRENULA Ach.

Syn. Lich. 125. 1814. (non Ach. Kongl. Vetensk. Akad. Nya Handl. 30: 160. 1809). Lectotype: *Sphaeria nitida* Weig.

The type of *Pyrenula* Ach. (1809) is the only species included, *P. margacea* Ach., now placed in *Verrucaria.* Thus, unless conserved, this widely used name will have to be dropped. The first time that species currently recognized as Pyrenulas were included was by Acharius in 1814. *Pyrenula nitida* was one of these species. Therefore, in order to preserve *Pyrenula* in its accepted sense, I would suggest that *Pyrenula* Ach. (1814) be typified with *Pyrenula nitida* and conserved over *Pyrenula* Ach. (1809).

Pyrenula has been considered ascohymenial (Kreisel, 1969). Chadefaud

(1960) placed it in the Verrucariales but in an appendix he relates it to *Aglaospora* in the "Pleosporales valsoïdes" in respect to spores and microconidia. Janex-Favre (1971), after a careful study of *Pyrenula nitida,* concludes it is most similar in development to primitive Discomycetes with bitunicate asci and may in fact be a perithecioid Discomycete. It is clearly distinct from ascolocular forms included in the Pleosporaceae. Until the relations of *Pyrenula* with other genera, such as *Strigula* and *Trypethelium,* are clarified, it seems best to recognize the family Pyrenulaceae Zahlbr. (1903) for *Pyrenula* and the closely related genera, *Melanotheca, Anthracothecium,* and *Bottaria.*

Pyrenula imperfecta (Ellis & Everh.) comb. nov.

Clypeosphaeria imperfecta Ellis & Everh., N. Amer. Pyrenomyc. 410. 1892. Type collection: Ellis & Everh. N. Amer. Fungi, 2nd ser., n. 1960. Syracuse, New York, *Underwood.* Isotypes in MSC & US.

Thallus olive, yellowish-olive to tan or yellowish-tan, UV−, shiny, often with scattered minute white dots, translucent in section, composed of compacted hyphae and bark cell remnants, 40-75 μ thick. *Trentepohlia* abundant and well-developed.

Ascocarps scattered, crowded or occasionally fused, brown-black, globose, subglobose, or occasionally somewhat flattened, mostly almost completely immersed, 0.4-0.8 mm in diameter. Ostiole usually flush with surface, rarely raised in a small papilla. Involucrellum usually entire, rarely lacking at base, brown-black, including bark cells and often including colorless crystals, 50-100(150) μ thick, thinner below. Exciple brownish, not distinct. Hymenium IKI+ pinkish-orange, occasionally initially bluish, inspersed with small granules or droplets. Interthecial hyphae ca. 1-2 μ, septate, not branched and anastomosing. Asci cylindrical-clavate, only slightly thicker at the tip, ca. 100-115 × 25-35 μ. Spores eight in the ascus, biseriate to rarely uniseriate, light brown, broadly elliptical, 3-septate (in abnormal forms up to 7-septate or submuriform with 5-7 irregularly arranged cells), commonly with true septa continuous with outer wall, terminal lumina shorter and broader than the median lumina, separated from outer spore wall by a layer of endospore, 24-35(46) × 10-15(17) μ (27.5-34 × 12.5-15 μ in type).

The diagnostic characters of *Pyrenula imperfecta* are the inspersed hymenium which is IKI+ orangish and the median lumina of the spore which are elongated in respect to the longitudinal axis. The white dots on the thallus separate it from the other Great Lakes species but may be lost due to erosion of the outer layers of thallus. The type has dots but they are lacking in 9 of 27 collections. Seven collections have spores with more than four locules. If one noticed only the submuriform spores, the collections might be erroneously assigned to the genus *Anthracothecium.* Since normal 4-loculate spores are also found in the same ascocarp, I do not believe that these forms merit any taxonomic recognition.

Pyrenula imperfecta is distributed mainly to the south of the Great Lakes region but occurs rarely in the eastern part. It has been collected on *Aesculus, Carya, Fagus, Hamamelis, Juglans, Liriodendron, Quercus,* and *Tilia.*

Illustrations: Figs. 52-53. Distribution: Fig. 67.

Specimens seen (Great Lakes only): Canada. Carleton County, Ottawa, *Macoun,* 6 Sept. 1891 (MICH).

United States. NEW YORK: Madison County, Oneida, sine coll. (FH); Onondaga County, Syracuse, *Underwood* (MSC, US).

Pyrenula laevigata (Pers.) Arn., Flora 68: 158. 1885.

Verrucaria laevigata Pers., Ann. Wetterauischen Ges. Gesammte Naturk. 2: 11. 1811.

Verrucaria glabrata Ach., Syn. Lich. 91. 1814 nom. illeg. *Pyrenula glabrata* (Ach.) Massal., Ricerch. Auton. Lich. 163. 1852. Type collection not seen.

This species has been more often called *Pyrenula glabrata,* but as Arnold (1855) indicated, *Verucaria glabrata* Ach. was an unnecessary new name for *V. laevigata* Pers.

Thallus endophloeodal, white, grayish, or rarely indicated only by a greenish color under the upper layer of bark. *Trentepohlia* abundant and well-developed.

Ascocarps scattered, occasionally 2-3 confluent, initially covered by a thin layer of bark, dark brown, hemispherical, 0.3-0.6 mm in diameter, 0.25-0.35 mm in height. Involucrellum entire or lacking below, brown-black, including bark cells, 50-100 μ thick, thinner below. Exciple brownish, not distinct. Hymenium IKI−, not inspersed. Interthecial hyphae occasionally branched, not anstomosed, septate, ca. 1 μ thick. Asci cylindrical-clavate to clavate, not much thickened at the tip, 40-70 × 10-15 μ. Spores eight in the ascus, biseriate to occasionally uniseriate, pale lavender-brownish, elliptical or rarely lemon-shaped, 4-locular with no distinct septa continuous with the outer spore wall, lumina separated only by the endospore, terminal lumina separated from the outer spore wall by a layer of endospore, 15-19(21) × 8-9(11) μ.

Pyrenula laevigata is characterized by its white thallus and spores with the lumina separated only by the endospore. The spore color is also quite distinctive but difficult to describe. It is more of a lavender-brown than a yellowish-brown as in the other Great Lakes species.

The spore size in American collections is somewhat less than in those of Europe, especially in width. The lengths are essentially comparable, but, based on a small sample, 90% of the spores from American collections are 8-9 μ broad while 90% of the European spores are 9-10 μ broad. One collection [Ontario, Ottawa, *Macoun,* 26 Apr. 1899 (US & LD as Macoun I: 68)] is identical with *P. laevigata* except for its larger size. The spores are 19-27 × 11-13 μ. Without additional material I prefer to retain it here as a possible variant of *P. laevigata.*

Pyrenula laevigata has been commonly reported in North America, but a vast majority of these reports are misidentifications. The species is relatively rare in the Great Lakes region. In Europe it occurs on *Carpinus, Fagus, Fraxinus,* and *Quercus,* while in North America it occurs mostly on *Betula lutea* and occasionally *Fraxinus.*

Illustration: Fig. 54.

Exsiccati examined: Hepp 227 (FH, FH-Tuck 4093); Rab. 87 (FH-Tuck 4093); Schaer. 110 (FH, FH-Tuck 4093).

Specimens seen: Canada. ONTARIO: Algoma District, Lake Superior Prov. Park, N of Doc Grieg Lake, *Harris 560, 569* (MSC); Carleton County, Carp, *Macoun,* 16 Oct. 1907 (CAN, FH); Nipissing District, Lake Timagami, *Cain 21643* (LD).

United States. MICHIGAN: Alger County, Kingston Lake, *Harris 618-B* (MSC); Cheboygan County, Douglas Lake, *Chamberlin,* 25 June 1960 (UMBS), *Harris 3617* (MSC); Chippewa County, NE of Trout Lake, *Harris 1043-A* (MSC); Delta County, NW of Isabella, *Harris 4230-A, 4241-A* (MSC); Dickinson County, O'Neil Lake, *Harris 7638* (MSC); Iosco County, Iargo Springs, *Harris 3786* (MSC). NEW HAMPSHIRE: County unknown, White Mtns., *Tuckerman* (FH-Tuck 4028). NEW YORK: Erie County, Buffalo, *Wilson,* 1875 (US).

Pyrenula macounii sp. nov.

Pyrenulae imperfectae similis sed differt hymenio non insperso, iodo non reagenti et sporis minoribus, 22-24 x 8-10 μ, cum luminibus medianis non vel parum elongatis.

Holotype: [Ontario], Belleville, *Macoun,* Apr. 1874 (CAN).

Thallus olivaceous, UV−, shiny, without white dots, translucent in section, composed of compacted hyphae and remnents of bark cells, ca. 75 μ thick.

Ascocarps quite crowded, brown-black, globose or subglobose, occasionally somewhat flattened at the base, immersed, 0.5-0.7 mm in diameter, 0.35-0.5 mm in height. Involucrellum entire, brown-black, including bark cells, colorless crystals absent, 40-100 μ thick, thinner below. Exciple brownish, not distinct. Hymenium IKI−, not inspersed. Interthecial hyphae ca. 1-2 μ, septate, not branched and anastomosed. Asci cylindrical, not much thickened at the tip, ca. 110-115 x 15-18 μ. Spores eight in the ascus, uniseriate, light brown, fusiform-elliptical, 3-septate, commonly with true septa continuous with the outer wall, terminal lumina separated from outer spore wall by a layer of endospore, 22-30 x 8-12 μ.

Pyrenula macounii is distinguished primarily by the uninspersed hymenium which does not react with iodine and by its spores which are similar to those of *P. imperfecta* but smaller and with less elongated median lumina.

Pyrenula macounii is known only by three collections from southern Ontario. The only substrate identified is *Carpinus.*

Illustration: Fig. 55.

Specimens seen: Canada. ONTARIO: Haldimand County, Canfield Junction, *Macoun,* 12 July 1892 (CAN); Hastings County, Belleville, *Macoun,* Apr. 1874 (CAN), Central Ontario Junction, *Macoun,* 24 Oct. 1893 (CAN).

Pyrenula neglecta sp. nov.

Species insignis *Pyrenulae,* thallo UV+ aureo (lichexanthone), hymenio IKI+ cyaneo et valde insperso, sporis 16-21 x 8-9.5 μ cum luminibus terminalibus juxta exosporium ab eo endosporio non separatis.

Holotype: Cum. I: 150. New Hampshire, Plymouth, on beech trees, *Cummings,* 26 Aug. 1893 as *P. nitida* (MSC). Isotypes in CAN, MSC, US & WIS as Cum. I: 150; in LD, MICH, & MSC as Cum. II: 161.

Thallus yellowish-olivaceous or grayish-green, UV+ yellow (lichexanthone), often shiny, upper layer ca. 100 μ thick, composed of compacted hyphae and bark cell remnants, somewhat cortex-like. *Trentepohlia* abundant, very well-developed, forming a definite layer below the cortex-like layer.

Ascocarp dark brown to black, dull to shiny, scattered or occasionally clustered and fused, hemispherical to subglobose, initially covered by bark and thallus but usually finally one-half to three-fourths emergent, 0.4-0.6 mm in diameter. Ostiole usually evident, flush with the ascocarp surface or often raised in a small papilla. Involucrellum dark brown, mostly lacking below or at least very thin below, containing bark cells, without colorless crystals, 50-60 μ thick. Exciple brownish, indistinct. Hymenium IKI+ greenish-blue at the base, heavily inspersed with oil droplets. Interthecial hyphae ca. 1 μ thick, septate, not branched. Asci cylindrical to somewhat clavate, tip not thickened, 70-85 × 15-18 μ. Spores eight in the ascus, mostly uniseriate, pale yellowish-brown, 3-septate, not constricted at the septa, terminal lumina smaller and pressed directly against the outer spore wall, often projecting and forming a small papilla at either end of the spore, 13-22(24) × (7)8-11(12) μ, (mean 17.6 ± 2.2 × 9.2 ± 0.8 μ based on 1549 spores).

Pyrenula neglecta is one of the most widely distributed pyrenolichens in eastern North America. Its local abundance and conspicuousness make it the most frequently collected. It has been most often misidentified as *P. nitida* (Weig.) Ach. but also as *P. laevigata* (or *P. glabrata*). Misidentifications as *P. laevigata* have, in fact, obscured the rare occurrence of *P. laevigata* in North America. *Pyrenula nitida* does not occur in North America, although the name has been used for a wide variety of species, and as far as I can tell is strictly European.[5] *Pyrenula neglecta* is characterized by the presence of lichexanthone in the thallus (verified by thin layer chromatography) although some specimens with badly eroded thalli do not fluoresce or fluoresce only toward the margins. Also diagnostic are the IKI+ greenish-blue hymenium which is heavily inspersed and the spores which have the terminal lumina directly against the outer spore wall. The thallus is never white-dotted and the ostiole is often raised in a small papilla.

Pyrenula neglecta is found in eastern North America from Newfoundland to northern Florida, west to Texas and Iowa. I have also verified two specimens from Japan. Material from western North America seems sufficiently distinct to merit taxonomic recognition. See additional notes p. 51.

[5]From rather limited material seen, the present usage of *P. nitida* represents a species complex whose most characteristic feature is that the terminal locules of the spores are usually constricted at the end walls of the lumina forming a solid conical cap of endospore at either end of the spore. Also the thallus is often white-dotted, the involucrellum usually contains colorless crystals, the hymenium is not inspersed, and the spore lumina are angular. The most common form of *P. nitida* has a layer of orange anthraquinone crystals in the subhymenium, which are KOH+ red, and has narrow spores. The form lacking the anthraquinone and having broad spores apparently has a more oceanic distribution. The var. *nitidella* with anthraquinone crystals has slightly broader spores than the comparable *nitida* form, while the spores of the *nitidella* form without the anthraquinone are indistinguishable from the comparable *nitida* form.

It most commonly occurs on the hard bark of *Fagus* and *Quercus* but also on *Acer rubrum, Acer saccharum, Alnus, Betula lutea, Carya, Celtis, Hamamelis, Leucothoe racemosa, Rhododendron maximum,* and *Tilia.*

Illustration: Fig. 56. Distribution: Fig. 66.

Exsiccati examined: Cum. I: 150 (CAN, MICH, MSC, US, WIS), II: 161 (FH-Riddle, LD, MICH, MSC); Macoun I: 68 (CAN, FH, MICH, US, WIS), II: 228 (CAN, FH, MSC, Thomson, US)[6]; Merr. I: 186 (CAN, FH, FH-Riddle, US); Rel. Far. 454 (US, WIS); Rel. Tuck. 131 (CAN, FH, MICH, MSC, Thomson, US, WIS).

Specimens seen (Great Lakes only): Canada. ONTARIO: Carleton County, Ottawa, *Macoun,* 1884 (FH-Tuck 4033), 16 Apr. 1891 (CAN), 26 Apr. 1891 (CAN, FH, MICH, US, WIS), Sept. 1891 (FH), 6 Sept. 1891 (CAN, FH, MSC, Thomson, US), 16 Apr. 1896 (CAN), 19 Apr. 1902 (CAN), 7 May 1907 (FH); Hastings County, Belleville, *Macoun,* 20 Apr. 1879 (CAN); Northumberland County, Seymour West, *Macoun,* 10 Oct. 1893 (CAN); Peel County, N of Palgrave, *Cain 26694* (US); Simcoe County, Devil's Glen, *Imshaug 26936, 26968* (MSC); Stormont County, Moose Creek, *Macoun,* 6 Sept. 1891 (CAN). QUEBEC: N of Chelsea, *Macoun,* 17 May 1907 (CAN, FH); Montmorency County, Montmorency Falls, *Macoun,* 7 July 1905 (FH), Montmorency River, *Macoun,* 29 June 1905 (CAN).

United States. ILLINOIS: Cook County, *Calkins* (FH, Thomson). IOWA: Black Hawk County, La Porte, *Peck,* 2 Jan. 1896 (US); Boone County, The Ledges, *Fink,* 27-8 July 1903 (MICH); Bremer County, *Fink,* 1895 (CAN, FH, US), 29 Aug. 1895 (CAN, FH, LD, MIN, US); Clayton County, Pikes Peak, *Imshaug 27896* (MSC); Delaware County, Backbone St. Park, *Imshaug 27998* (MSC); Fayette County, *Fink,* Apr. 1894 (FH, LD, MICH, MIN, WIS); Jackson County, Maquoketa Caves Park, *Imshaug 28063* (MSC). MICHIGAN: Alger County, Au Train, *Lowe 1555* (FH, MICH, US), *1567* (MICH, US); Benzie County, Benzie St. Park, *Bayliss 41* (MSC), *Imshaug 27419* (MSC); Charlevoix County, Beaver Island, *Imshaug 27588, 27645* (MSC); Cheboygan County, Burt Lake, *Nichols,* 1923 (FH, MICH), Douglas Lake, Gorge, *Imshaug 3137* (MSC), Grapevine Point, *Evans,* 4 Aug. 1960 (UMBS), *Nichols,* 1922 (FH, UMBS); Crawford County, Hartwick Pines St. Park, *Imshaug 21385* (MSC); Emmet County, N of Cross Village, *Olexia,* 19 July 1966 (UMBS), SW of Cross Village, *Engel 1118* (MSC), S of Mackinaw City, *Sierk,* 18 July 1957 (WIS), Sturgeon Bay, *Berlin 144* (UMBS), Sturgeon Point, *Stevenson,* 27 July 1965 (UMBS); Houghton County, near Calumet, *Imshaug 20852* (MSC); Iosco County, Iargo Springs, *Harris 834* (MSC); Luce County, Upper Tahquamenon Falls, *Imshaug 19890* (MSC); Mackinac County, Bois Blanc Is., *Imshaug 3309* (MSC), *Piehl,* 2 Aug. 1958 (UMBS), Mackinac Is., *Imshaug 27244* (MSC); Washtenaw County, NW of Crooked Lake, *Harris,* 9 May 1964 (MSC). MINNESOTA: County unknown, Minneapolis, *Fink,* 1896 (CAN); Blue Earth County, Mankato, *Fink 211* (MIN); Brown County, New Ulm, *Fink 222* (MIN). NEW YORK: Cortland County, Homer, *Green,* Aug. 1885 (FH); Onondaga County, Manlius, *Cook,* May 1887 (US);

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[6]Since I have examined a number of duplicates of Macoun's *Canadian Lichens* issued as *Pyrenula nitida,* it seems worthwhile to comment on the reliability of these exsiccati. Of eight duplicates of I: 68, six are *P. neglecta,* one (MSC) is a non-lichenized fungus on white oak not beech, and another (LD) is a large spored form of *P. laevigata.* The latter is certainly part of the only known collection of this variant cited under that species. One of the six (MICH) has an inner packet marked "10/4/80 148" (the date on the printed label is 26 Apr. 1891). Of seven duplicates of II: 228, six are *P. neglecta* and one (MICH) is *P. imperfecta.* The collection, according to the printed label, was made at Ottawa, 6 Sept. 1891. However, a collection of *P. neglecta* in Macoun's herbarium is labelled as having been collected at Moose Creek on that date and bears the collection number 536. Two duplicates of II: 228 (FH, Thomson) contain slips marked "536 6/9/91." The distance between Ottawa and Moose Creek makes it unlikely that Macoun collected at both on the same day. Thus, as Culberson (1959) has stated, there are two or more collections distributed under a given number.

Yates County, Penn Yan, *Sartwell,* 1852 (FH-Tuck 4032). OHIO: Lake County, Painesville, *Werner,* 13 July 1892 (FH); Lorain County, Stony Brook, *Grover,* July 1913 (MSC). WISCONSIN: Door County, Valmy, *Culberson 3619* (WIS); Grant County, *Hale 1129* (WIS); Green Lake County, *Hale 1018* (WIS); Sauk County, Baraboo Range, *Thomson 1401* (Thomson, WIS); Vernon County, *Hale 1226* (WIS); Washburn County, near Long Lake, *Culberson 1730* (WIS).

TRYPETHELIUM Spreng.

Anleitung Kenntn. Gewächse, 3: 350. 1804. nom. cons. (syn. prius *Bathelium* Meth. Lich. iii. 1803). Holotype: *Trypethelium eluteriae* Spreng.

The genus may be defined by the ascocarps embedded in a pseudostroma, interthecial hyphae branched and anastomosed forming a loose and rather regular reticulum, and colorless, transversely septate spores with lumina oval, angular, or cross-shaped in optical section.

Trypethelium is usually taken as the type of a family, Trypetheliaceae Eschw. (1824), based on the inclusion of the ascocarps in a stroma. Zahlbruckner (1926) includes four other genera in the family: *Bottaria, Laurera, Melanotheca,* and *Tomasellia. Melanotheca* and *Bottaria* clearly belong in the Pyrenulaceae. *Tomasellia* should probably be placed in the Pleosporaceae and may be congeneric with *Mycoporellum.* Although Vězda (1968) removes *Laurera* to a separate group along with some species of *Polyblastiopsis,* I feel it should be retained in the Trypetheliaceae with *Trypethelium.* Chadefaud (1960) places *Trypethelium* in a separate ascohymenial order, Trypetheliales (Pyreno-lichens Sphaeriaceens), possibly related to the Sordariales. Vězda (1968) has found the asci of both *Laurera* and *Trypethelium* to be bitunicate. Kreisel (1969) includes the family in the Dothideales. It seems clear definitive studies are required before *Trypethelium* can be placed in the system with certainty.

Trypethelium virens Tuck. in W. Darl. Fl. Cest. ed. 3. 453. 1853.

Description modified from Johnson (1959). Thallus endophloeodal, smooth, greenish, yellowish-gray, yellow-brown, or orange-brown, upper layer composed of compacted hyphae and bark cell remnants, cortex-like, 45-90 μ thick. *Trentepohlia* abundant, well-developed, in a layer 15-23 μ thick.

Ascocarps aggregated and embedded in a pseudostroma which may be up to 7 mm in length, slightly elevated, ± concolorous with the thallus (especially when young) but often becoming lighter or darker with age, outer layer consisting of bark cells and up to 55 μ thick. Ascocarp initials forming below this layer raise the bark layer as the perithecia enlarge, sometimes altering the bark cells to a blackish color or interwoven hyphae becoming carbonaceous. Ascocarps 0.4-0.6 mm high by 0.2-0.5 mm across. Ostioles seen from above as brown or black dots ca. 0.1 mm in diameter. Ascocarp wall entire, carbonaceous, 30-60 μ thick. Interthecial hyphae ca. 1 μ thick, anastomosed, forming a loose net. Asci clavate to clavate-cylindrical, 100-125 × 15-17 μ. Spores eight in the ascus, irregularly biseriate, colorless, 7-9-septate, not constricted at the septa, lumina elliptical or diamond-shaped in optical section, 38-52 × 7-10 μ.

Pycnidia large, embedded in the pseudostroma, labyrinthiform. Conidiophores long and thin. Microconidia colorless, rod-like, ca. 5 × 1 μ.

This species is of special interest as it is the only Great Lakes representative of a very large tropical group which is highly developed along stromatic lines.

Trypethelium virens is widely distributed in North America from Wisconsin to Florida but apparently does not occur north of the Straits of Mackinac. It grows on *Carpinus* and *Fagus* in the Great Lakes region.

Illustration: Fig. 57. Distribution: Fig. 68.

Exsiccati examined: Cum. I: 253 (CAN, MSC), II: 193 (MICH, MSC); Macoun I: 116 (CAN, MSC, US), II: 226 (US); Merr. I: 69 (MICH, US); Rel. Far. 456 (MICH); Rel. Tuck. 146, 147b (MSC); Zahl. 231 (MICH).

Specimens seen (Great Lakes only): Canada. ONTARIO: Carleton County, Ottawa, *Macoun,* 20 Apr. 1891 (CAN), 6 Sept. 1891 (CAN, MSC, US), 11 Oct. 1893 (US), 16 Apr. 1896 (CAN); Frontenac County, Kingston, *Drummond,* 1864 (FH-Tuck 4032); Hastings County, Belleville, *Macoun,* 1879, 1882 (CAN); Northumberland County, Brighton, *Macoun,* 16 Oct. 1893 (CAN); Parry Sound District, Parry Sound, Indian Docks, *Cain 26671* (US, WIS); Simcoe County, Devil's Glen, *Imshaug 26975, 26992* (MSC).

United States. INDIANA: Tippecanoe County, Lafayette, *Fink 349* (US). MICHIGAN: Benzie County, Benzie St. Park, *Bayliss 41* (MSC); Charlevoix County, Beaver Island, *Imshaug 27490* (MSC); Cheboygan County, Douglas Lake, Gorge, *Nichols,* 1923 (MICH), Grapevine Point, *Leeson,* 1921 (UMBS), Reese's Bog, *Nichols,* 1922 (UMBS), E of Wolverine, *Harris 783, 784* (MSC); Clinton County, W of Grand Ledge, *Harris 3751* (MSC); Eaton County, near Vermontville, *Imshaug 29231, 29232* (MSC); Emmet County, Sturgeon Bay N of Cross Village, *Robinson & Crum,* 16 July 1958 (UMBS); Ingham County, Mich. State University, *Harris 62, 77* (MSC); Mason County, N of Ludington, *Harris 6074* (MSC). NEW YORK: Essex County, Mt. McIntyre, *Thomson 11118* (WIS); Hamilton County, 6 mi S of Sabael, *Brodo 2845* (CAN); Tompkins County, Slaterville, *Cain 25227* (US). OHIO: Lake County, Painesville, *Fink 649* (MICH). WISCONSIN: Door County, near Jacksonport, *Culberson 3709, 3913* (WIS).

DOUBTFUL OR EXCLUDED SPECIES

Arthopyrenia alba (Schrad.) Zahlbr. This name has been frequently used in North America but all the specimens examined have been other species, most commonly *A. biformis, A. cavata,* or *A. finkii.*

Arthopyrenia epidermidis auct. The name is based on *Lichen epidermidis* Ach. (= *Leptorhaphis epidermidis* (Ach.) Th. Fr.). North American specimens are usually *Arthopyrenia punctiformis* or *A. fraxini.*

Arthopyrenia gemmata (Ach.) Massal. This name has been used many times in North America, but every specimen so far examined has been misidentified. Specimens most often are *A. biformis* but also commonly *A. cavata* and *A. finkii.* (See discussion under the last two species.) In my opinion *A. gemmata* should be excluded from the North American flora.

Arthopyrenia sphaeroides (Wallr.) Zahlbr. The name is a synonym of *Arthopyrenia gemmata.* North American records are either *A. biformis* or *A. cavata.*

Arthopyrenia subpunctiformis Nyl. The report by Nichols (1925) is based on a mixture of an *Arthonia* and an immature pyrenocarpous fungus (FH, UMBS).

Microthelia micula var. *quadriloculata* (Fink) Zahlbr., Cat. Lich. Univ. 1: 263. 1921. *Pyrenula cinerella* var. *quadriloculata* Fink, Minnesota Bot. Stud. 2: 276. 1899. Holotype: Minnesota, Grand Portage Island, *Fink 85* (MICH).

Isotypes in MIN, MSC, & US. The type collection consists of *Polyblastiopsis fallaciosa* mixed with unrelated pycnidia containing macroconidia which are brown, oblong and 3(4)-septate with an occasional longitudinal septum. Fink's taxon is clearly based on these pycnidia. It should be removed from *Microthelia* and should not be considered a synonym of *P. fallaciosa.*

Polyblastiopsis fallax (Nyl.) Fink. Nylander's species is *Arthopyrenia fallax* (Nyl.) Arn. and does not occur in the Great Lakes region. Fink's misapplication of the epithet is *Polyblastiopsis fallaciosa.*

Porina nucula Ach. var. *heterospora* Fink ex Hedrick. A specimen from Merrill's herbarium, MICHIGAN: sine loc., *Bogue 180* (FH as *Pyrenula olivacea*), is identical with Fink's taxon. However, as far as I have been able to determine, it does not occur north of Kentucky. The majority of Bogue's collections are from central and southern Ohio. Since there are no other collections of the genus *Porina* from the Great Lakes region, I feel the genus is best excluded from the Great Lakes flora.

Pyrenula nitida (Weig.) Ach. North American records are misidentifications. See p. 46.

ADDITIONAL NOTES

For the sake of clarity I include a description of the fungus which has been confused with *Eopyrenula leucoplaca.* R. A. Shoemaker (in litt.) has suggested that it is an undescribed species of *Melanomma.*

"Thallus" white powdery, apparently consisting of exfoliating dead bark cells.

Ascocarps scattered, black, hemispherical, ca. 0.1 mm in diameter, mostly immersed in the loosened bark cells. Ascocarp wall entire, brown, 25-45 μ thick. Hymenium IKI−. Interthecial hyphae ca. 1 μ thick, septate, much branched and anastomosed. Asci cylindric to clavate-cylindric, tip not much thickened, inner wall not indented, 60-80 x 12-15 μ. Spores eight in the ascus, biseriate, brown, elliptic-fusiform, 3-septate, usually strongly constricted only at the median septum, spore halves equal, or more commonly unequal and the upper part broader, heavy gelatinous sheath clearly evident in KOH, 15-24 x 6-8 μ.

Known only from the living bark of *Populus tremuloides.* All of Wetmore's (1968) material of *Pyrenula leucoplaca* from the Black Hills belongs here. The species is also apparently common in the northwestern Great Lakes region, reaching its southern limit just below the Straits of Mackinac. It occurs rarely east to New Hampshire.

Illustrations: Fig. 29; Fink, 1910, pl. 49; 1935, pl. 2.

Specimens seen (Great Lakes only): Canada. ONTARIO: Carleton County, Stittsville, *Macoun,* 14 May 1897 (CAN); Thunder Bay District, 15 mi W of Marathon, *Brodo 6493* (CAN). QUEBEC: Hull County, East Templeton, *Macoun,* 22 May 1902 (CAN).

United States. MICHIGAN: Alger County, Rock River, *Lowe 2205, 2229* (MICH); Cheboygan County, E of Wolverine, *Harris 786* (MSC); Dickinson County, O'Neil Lake, *Harris 7385* (MSC); Iron County, S of Kenton, *Harris 718* (MSC); Keweenaw County, Isle Royale, Hay Bay, *Lowe 741* (MICH), McCargo Cove, *Lowe 276* (MICH), Rock Harbor, *Lowe 151* (FH, MICH, US); Menominee County, N of Cedar River, *Harris 751* (MSC). MINNESOTA: Beltrami County, Bemidji, *Fink 611* (CAN, MIN); Blue Earth County,

Mankato (Rapidan), *Fink 180* (MIN); Cook County, Grand Marais, *Fink,* 31 July 1902 (MICH, MIN), Grand Portage Island, *Fink* (MICH), Gunflint, *Fink 391* (MIN), Misquah Hills, *Fink 507* (MIN), Rose Lake, *Fink 209* (MICH, MIN, MSC, Thomson); Koochiching County, Emo, *Fink 682* (MIN), Flag Island, *Fink 549* (MIN), Koochiching, *Fink 877* (MIN), Rainy Lake City, *Fink 1236* (MIN); Lake County, Snowbank Lake Area, *Fink 852* (MIN), s.n. (FH, US); Lake of the Woods County, Beaudette, *Fink 138* (MIN); Otter Tail County, Henning, *Fink 344* (MIN), Leaf Hills, *Fink 268* (MICH, MIN), *269* (MIN), Red Lake, *Fink 961* (MIN); Pennington County, Thief River Falls, *Fink 767* (MICH, MIN), *802* (MIN); Roseau County, Warroad, *Fink 149* (MIN); St. Louis County, Ely, *Fink 1009* (MIN), Harding, *Fink 1582* (MIN), *1591* (MICH), Tower, *Fink 1813* (MIN).

Pyrenula neglecta subsp. **occidentalis** subsp. nov.

Pyrenulae neglectae similis sed thallo UV- et sporis parum majoribus, 20-23 × 8-11 μ.

Holotype: Merr. I: 275. Washington, Gate, *Foster,* 30 Mar. 1912, on vine maple (MSC). Isotypes in CAN, FH, FH-Riddle, & MICH.

Thallus yellowish, UV-, lacking lichexanthone, often thin and discontinuous. Ascocarp and hymenium essentially as in subsp. *neglecta.* Spores similar in form but slightly larger than in *neglecta,* 17-24 × 8-12 μ (mean 20.2 ± 1.8 × 10.1 ± 1.1 μ based on 162 spores).

Western collections of *Pyrenula neglecta* were originally thought to be identical with eastern ones. Further study brought to light the two differences noted above, which, coupled with a distinct distribution, suggest recognition at the subspecies level.

I have verified a single collection of this subspecies from easternmost Siberia. Otherwise this subspecies ranges along the coast from Vancouver Island to northern California. The type is on *Acer circinatum,* others on *Alnus* and *Cornus,* while the California collection is on *Abies.*

Distribution: Fig. 66.

Exsiccati examined: Merr. I: 275 (CAN, FH, FH–Riddle, MICH).

Specimens seen: Canada. BRITISH COLUMBIA: Vancouver Island, Saanichton, *Macoun,* 29 Sept. 1914 (FH), Sidney, *Macoun,* Sept. 1913 (FH).

United States. CALIFORNIA: Mendocino County, Mendocino, *Bolander 354* (FH-Tuck 4032). OREGON: Tillamook County, Garibaldi, *Sweetser,* July 1899 (FH, US), near Tillamook, *Sweetser* (FH). WASHINGTON: Clallam County, Cape Flattery, *Smith 1890a* (MICH), *1895* (FH, MICH), *13151* (MICH); Cowlitz County, Vancouver, *Pringle,* 15 Nov. 1881 (FH, FH-Tuck 4032, MSC); Thurston County, Gate, *Foster,* 12 Jan. 1912 (FH, MICH, US), 30 Mar. 1912 (CAN, FH, FH-Riddle, MICH), 15 Apr. 1912 (FH), 5 May 1912 (FH-Riddle, US).

ACKNOWLEDGMENTS

I wish to thank the curators of all the herbaria from which I have borrowed specimens but especially P. W. James for slides of Acharian material in the British Museum and T. Ahti for the loan of Nylander types. I am greatly indebted to H. A. Imshaug for preparing slides of Acharian material in Helsinki, for continuing support of this work, and for invaluable editorial advice.

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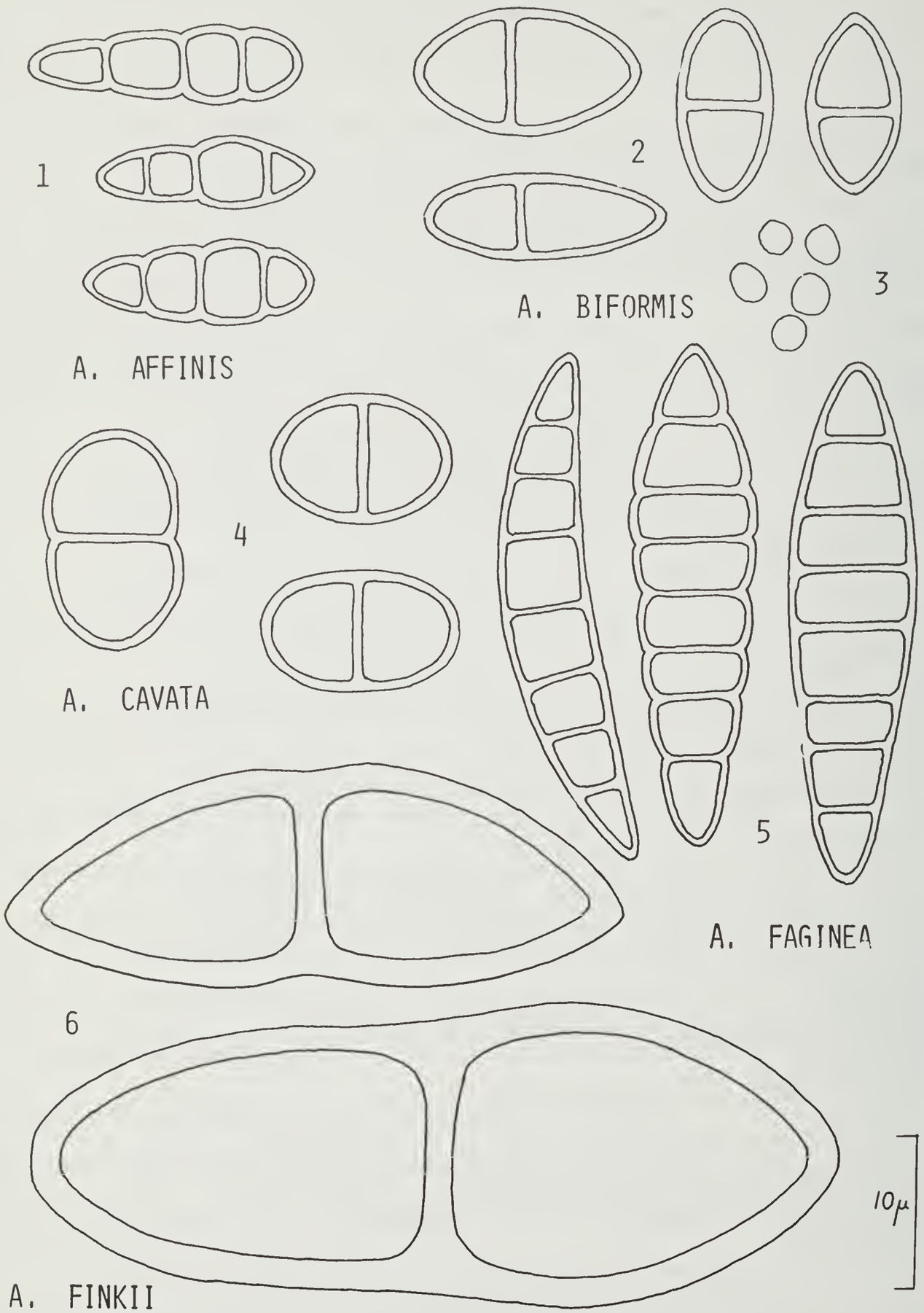

Fig. 1. *Arthopyrenia affinis,* spores. 2. *A. biformis,* spores. 3. *A. biformis,* microconidia. 4. *A. cavata,* spores. 5. *A. faginea,* spores. 6. *A. finkii,* spores.

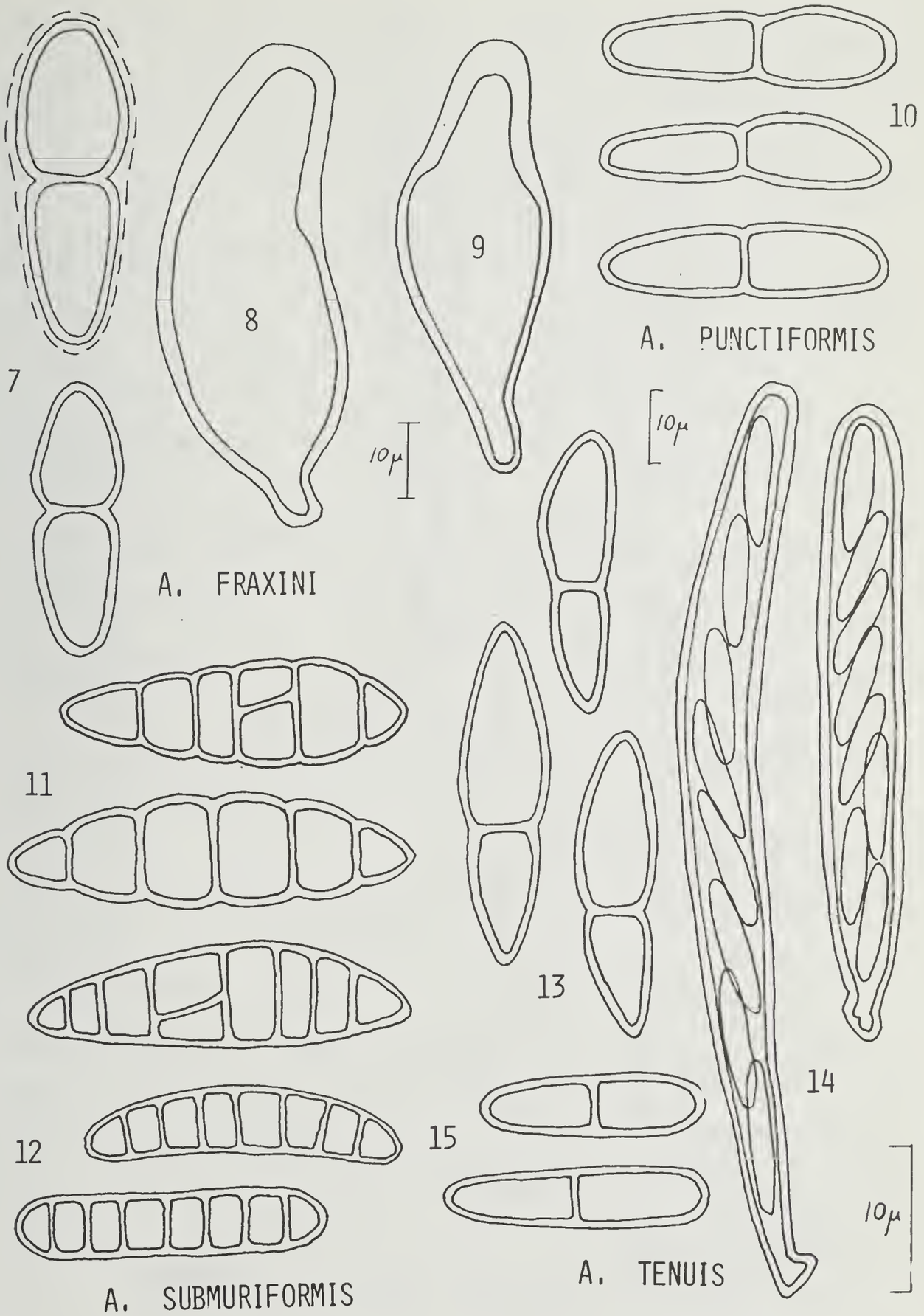

Fig. 7. *Arthopyrenia fraxini,* spores. 8. *A. fraxini,* ascus. 9. *A. punctiformis,* ascus. 10. *A. punctiformis,* spores. 11. *A. submuriformis,* spores. 12. *A. submuriformis,* macroconidia. 13. *A. tenuis,* spores. 14. *A. tenuis,* asci. 15. *A. tenuis,* macroconidia.

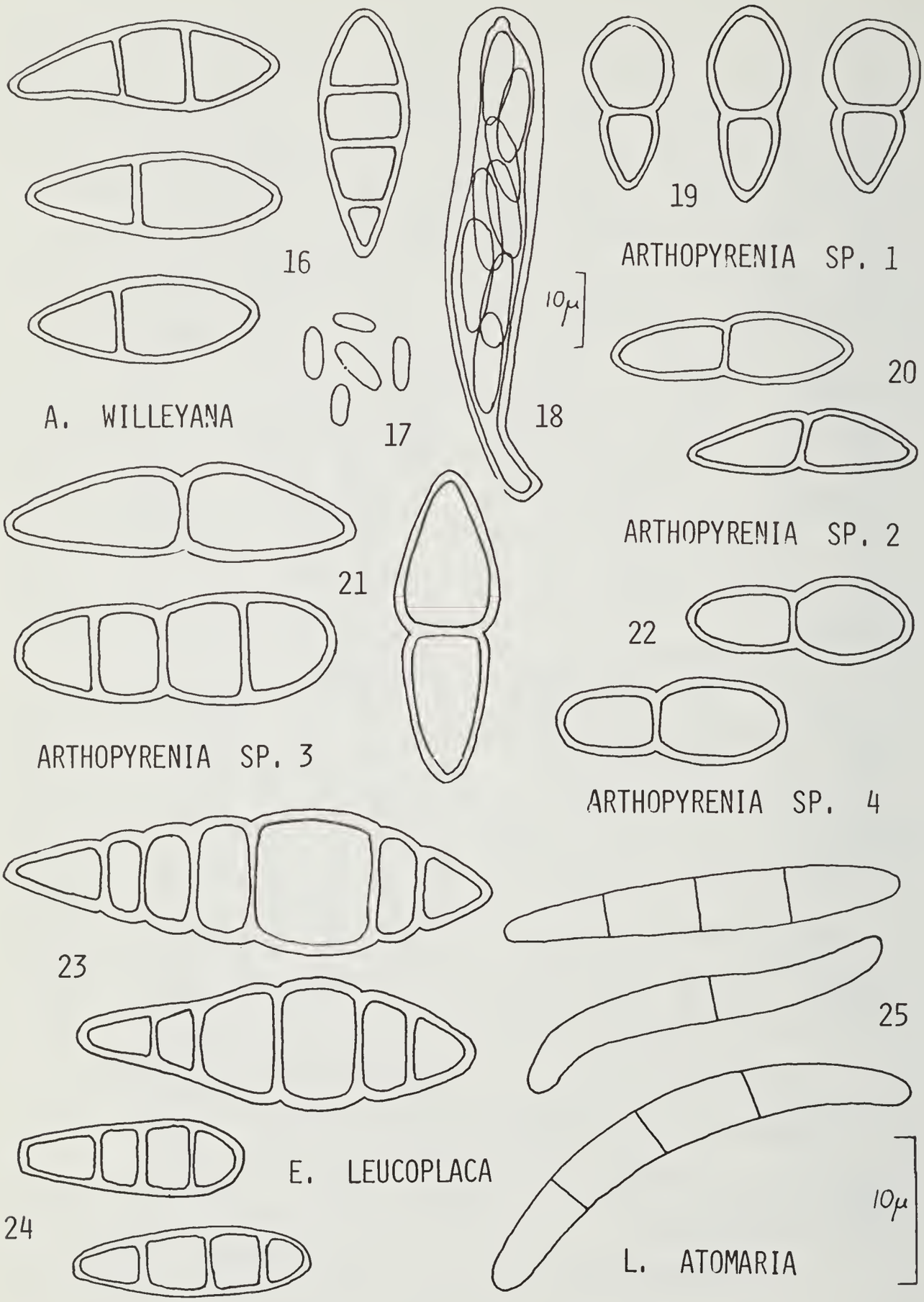

Fig. 16. *Arthopyrenia willeyana,* spores. 17. *A. willeyana,* microconidia. 18. *A. willeyana,* ascus. 19. *Arthopyrenia* sp. 1, spores. 20. *Arthopyrenia* sp. 2, spores. 21. *Arthopyrenia* sp. 3, spores. 22. *Arthopyrenia* sp. 4, spores. 23. *Eopyrenula leucoplaca,* spores. 24. *E. leucoplaca,* macroconidia. 25. *Leptorhaphis atomaria,* spores.

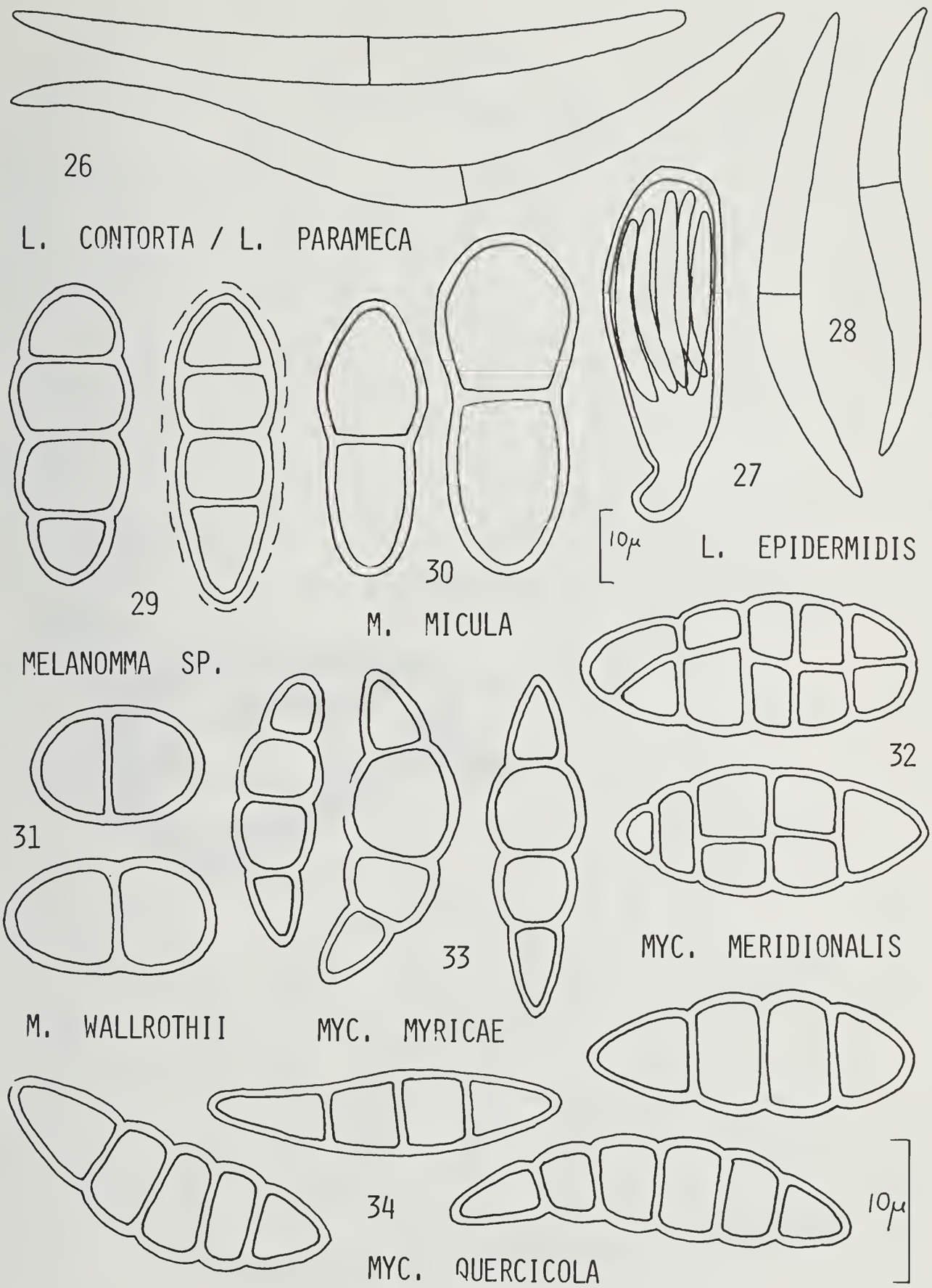

Fig. 26. *Leptorhaphis contorta/L. parameca,* spores. 27. *L. epidermidis,* ascus. 28. *L. epidermidis,* ascus. 29. *Melanomma* sp., spores. 30. *Microthelia micula,* spores. 31. *M. wallrothii,* spores. 32. *Mycoglaena meridionalis,* spores. 33. *Myc. myricae,* spores. 34. *Myc. quercicola,* spores.

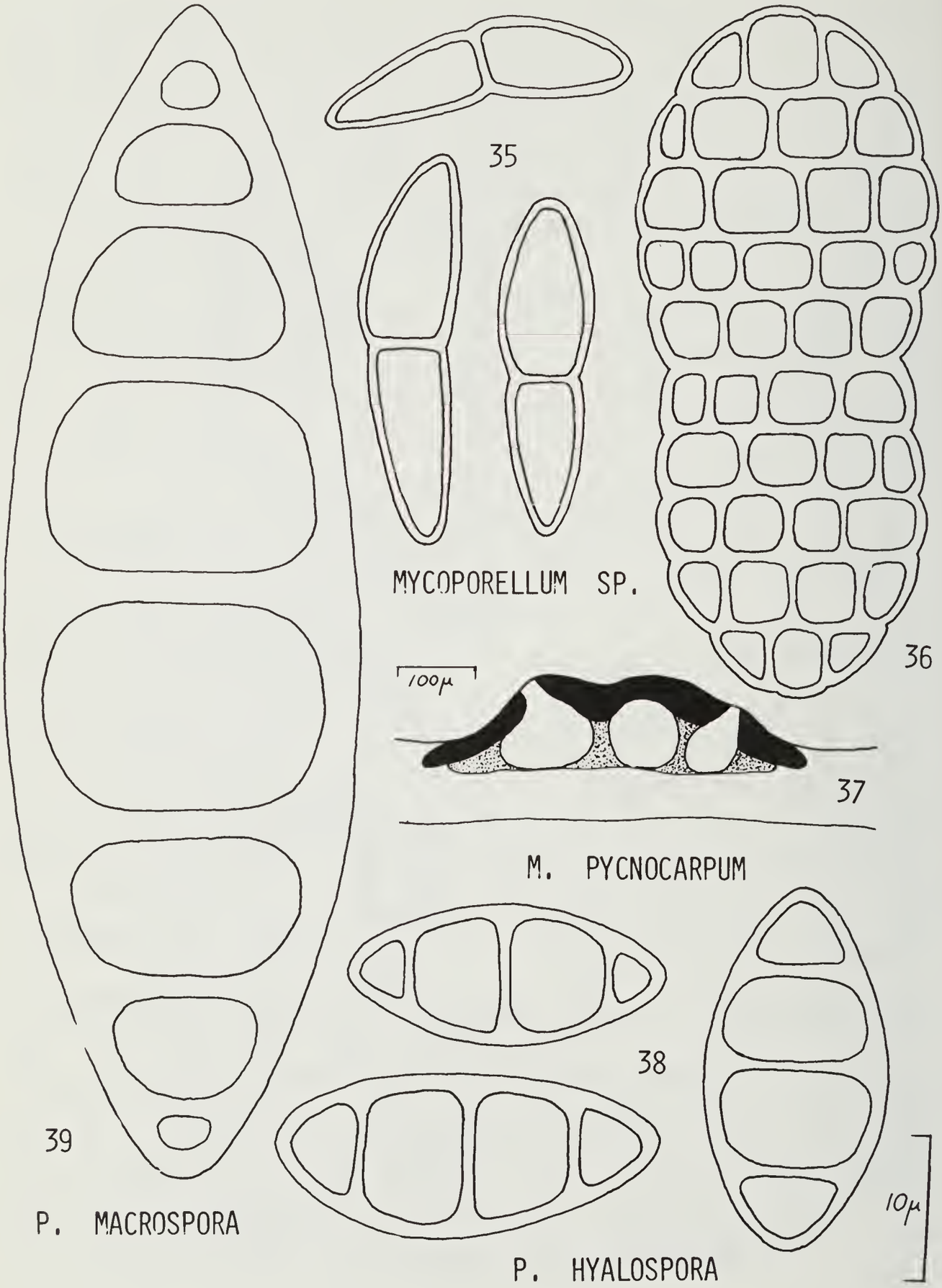

Fig. 35. *Mycoporellum* sp., spores. 36. *Mycoporum pycnocarpum,* spore. 37. *M. pycnocarpum,* section of ascocarp. 38. *Plagiocarpa hyalospora,* spores. 39. *P. macrospora,* spore.

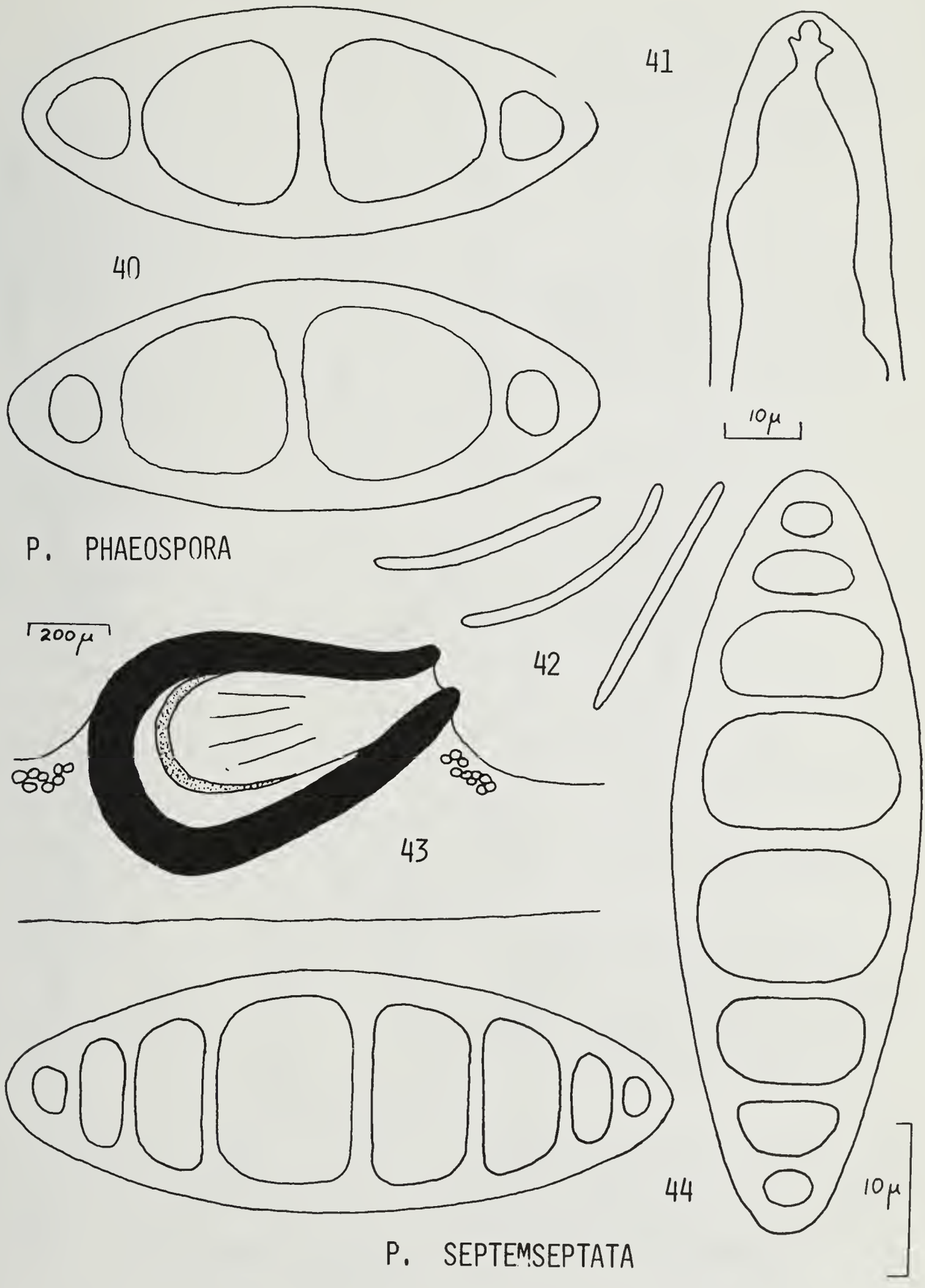

Fig. 40. *Plagiocarpa phaeospora,* spores. 41. *P. phaeospora,* ascus tip. 42. *P. septemseptata,* microconidia. 43. *P. septemseptata,* section of ascocarp in dry state. 44. *P. septemseptata,* spores.

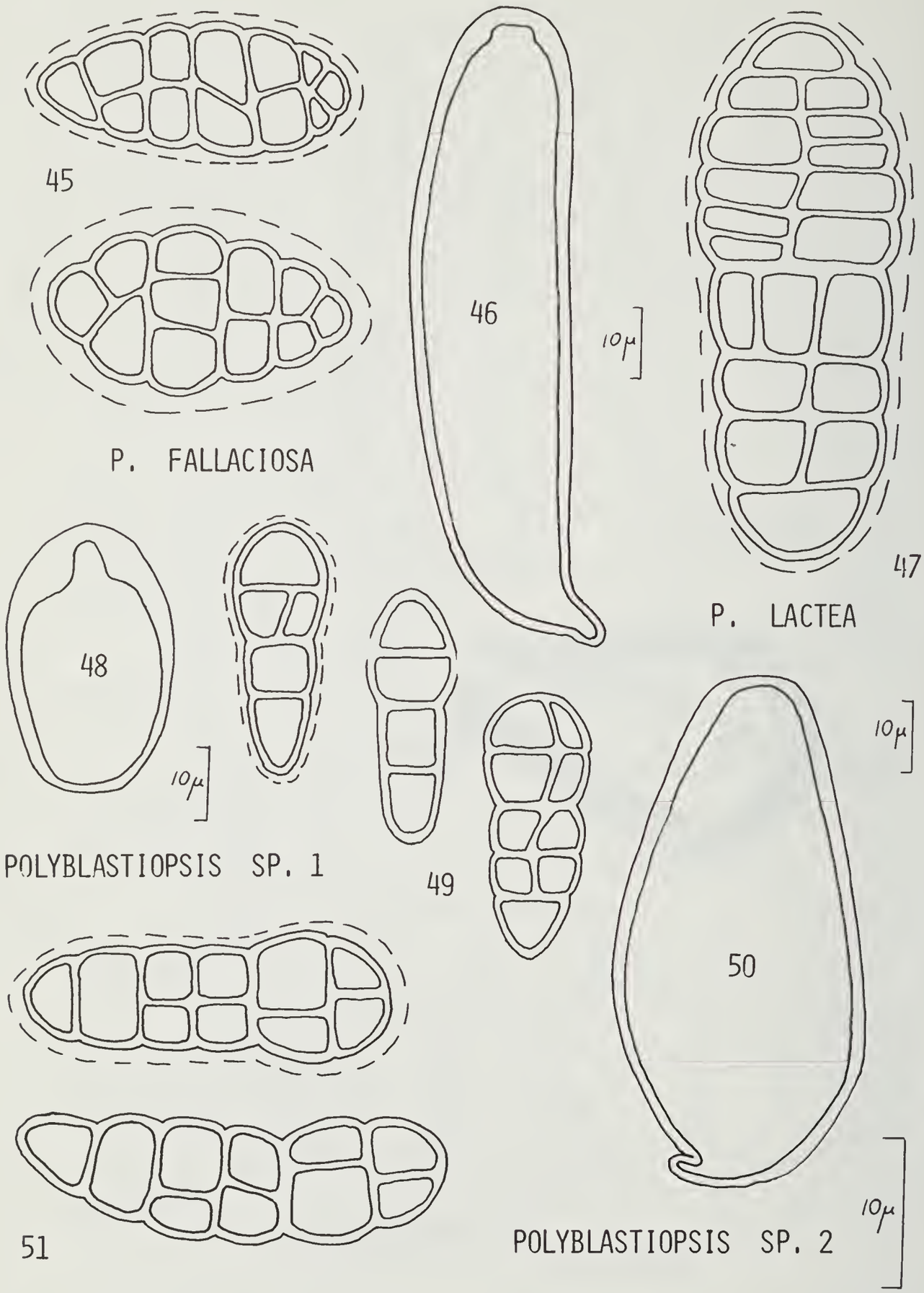

Fig. 45. *Polyblastiopsis fallaciosa,* spores. 46. *P. fallaciosa,* ascus. 47. *P. lactea,* spore. 48. *Polyblastiopsis* sp. 1, ascus. 49. *Polyblastiopsis* sp. 1, spores. 50. *Polyblastiopsis* sp. 2, ascus. 51. *Polyblastiopsis* sp. 2, spores.

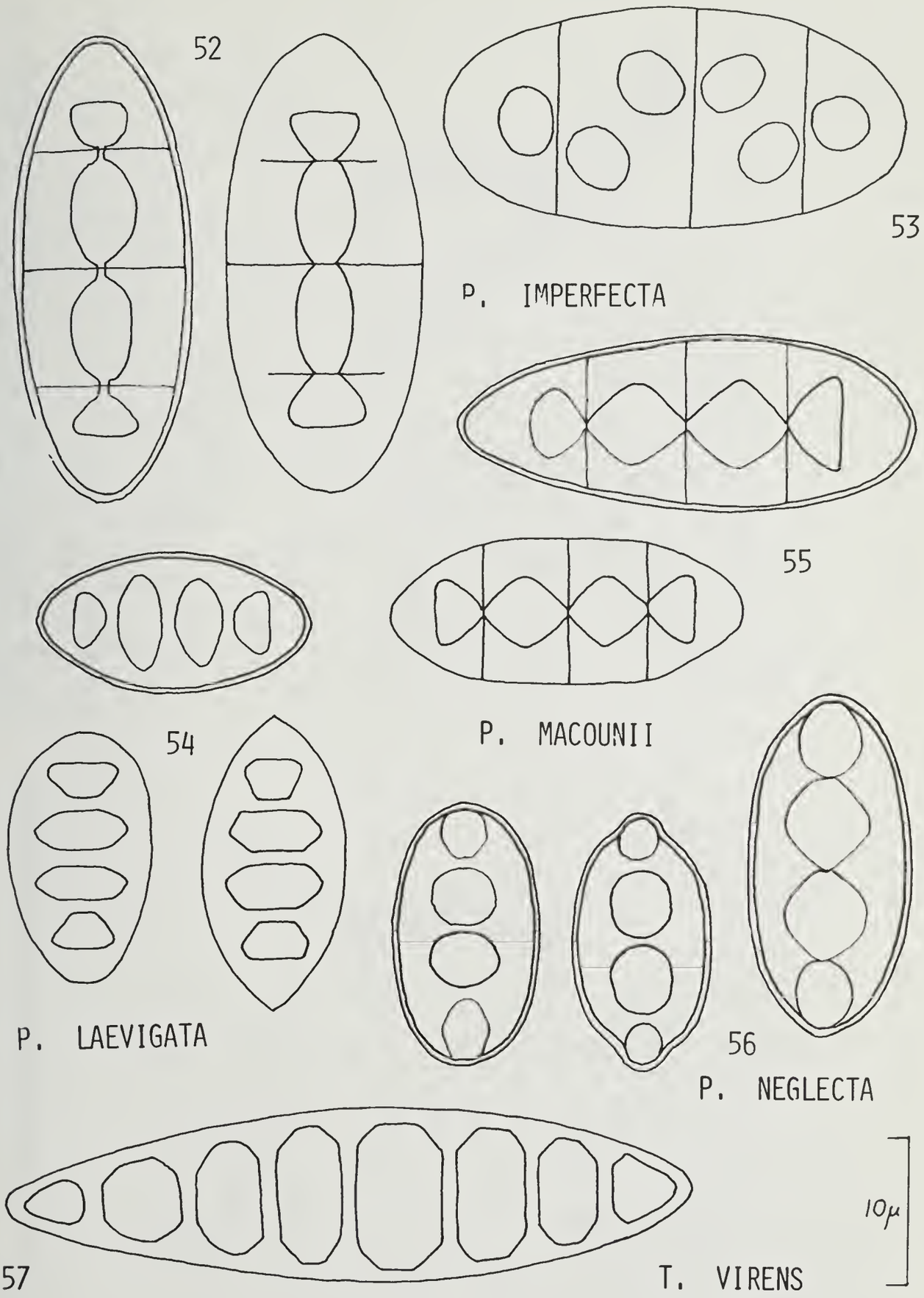

Fig. 52. *Pyrenula imperfecta,* spores. 53. *P. imperfecta,* abnormal spore. 54. *P. laevigata,* spores. 55. *P. macounii,* spores. 56. *P. neglecta,* spores. 57. *Typethelium virens,* spore.

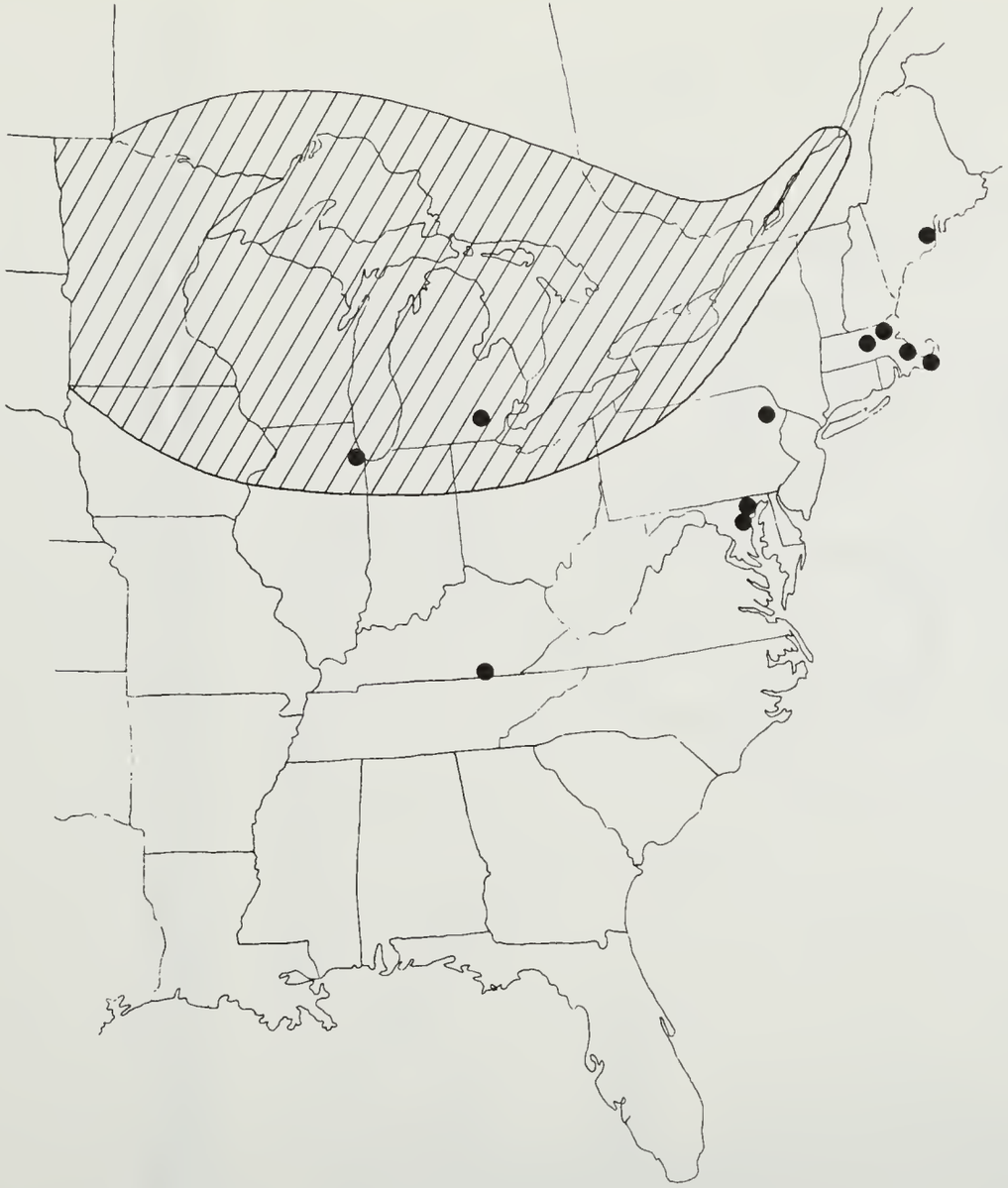

Fig. 58. Distribution of *Arthopyrenia biformis*. Hatching indicates Great Lakes region.

Fig. 59. Distribution of *Arthopyrenia finkii*. Hatching indicates the Northern Division of the Oak-Hickory Forest Region and the Oak-Chestnut Forest Region after Braun (1950).

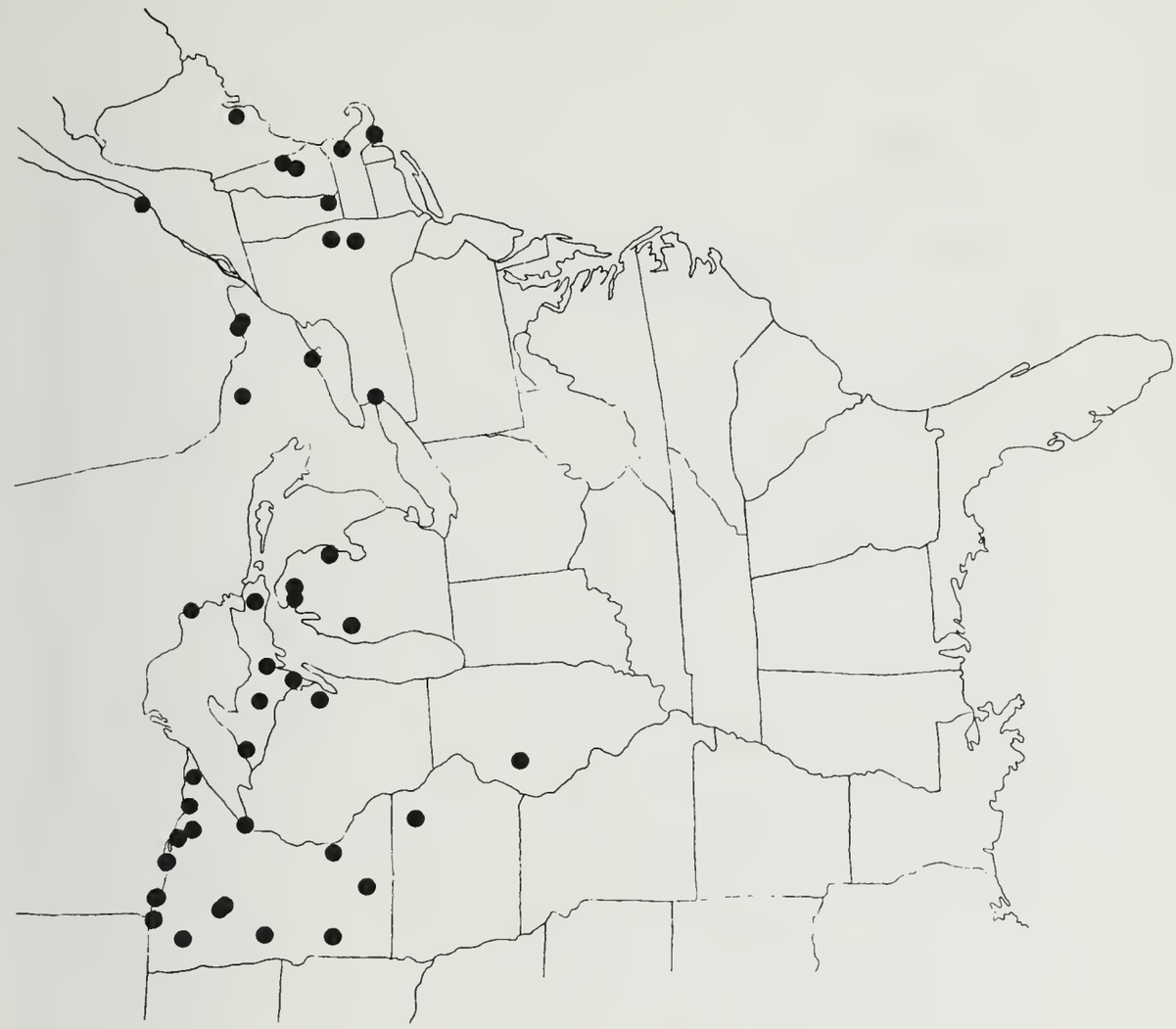

Fig. 61. Distribution of *Eopyrenula leucoplaca*.

Fig. 60. Distribution of *Arthopyrenia willeyana*.

Fig. 63. Distribution of *Mycoporum pycnocarpum*.

Fig. 62. Distribution of *Leptorhaphis epidermidis*.

Fig. 65. Distribution of *Polyblastiopsis fallaciosa.*

Fig. 64. Distribution of *Plagiocarpa hyalospora.*

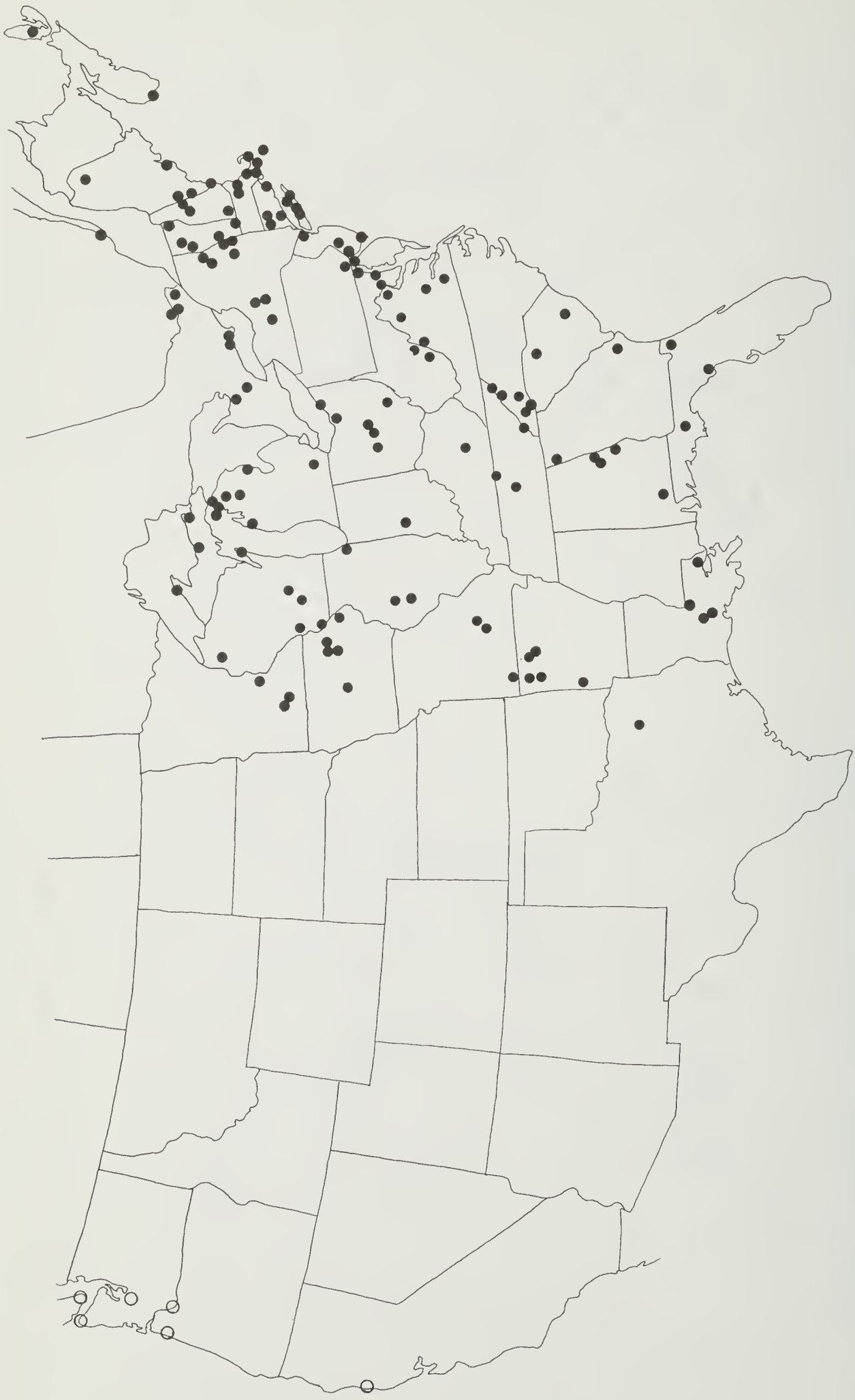

Fig. 66. Distribution of *Pyrenula neglecta* subsp. *neglecta* and subsp. *occidentalis* (open circles).

Fig. 68. Distribution of *Trypethelium virens.*

Fig. 67. Distribution of *Pyrenula imperfecta.*

INDEX

ACROCORDIA, 8, 9
acuminans, 28
aeruginella, 29
affinis, 9, **10**
alba, 49
albissima, 23
ANTHRACOTHECIUM, 43
ARTHOPYRENIA, 8
atomaria, **22**
biformis (Arthopyrenia), 9, **10**, 11
biformis (Microthelia), 26
BOTTARIA, 43, 48
BLASTODESMIA, 19
cavata, **11**, 13
cinerescens, 28
contorta, **22**
corrosa, 38
CYRTIDULA, 32
DERMATINA, 31
DERMATOCARPON, 3
DIDYMOSPHAERIA, 25
elabens, 31
EOPYRENULA, **19**
epidermidis, **23**, 49
faginea, 9, **12**
fallaciosa, **38**, 41
fallax, 39, 49
farrea, 19
finkii, **12**
flotowianum, 31
frankliniana, 39, 40
fraxini, 9, **13**
gemmata, 11, 13, 49
gemmata v. macrocarpa, 13
glabrata, 44
halodytes, 9
hyalospora, **34**
imperfecta, **43**
lactea, **41**
laevigata, **44**, 46
LAURERA, 48
LEIOPHLOEA, 8
LEPTORHAPHIS, **21**
leucoplaca, **19**, 50
leucoplaca v. pluriloculata, 19, 20
LITHOTHELIUM, 34
macounii, **45**
macrocarpa, 13
macrospora (Arthopyrenia), 13
macrospora (Plagiocarpa), **36**
megalospora, 13
MELANOMMA, 50
MELANOTHECA, 43, 48
meridionalis, **28**
MICROGLAENA, 28, 38
MICROTHELIA, **25**
micula, **26**
micula v. quadriloculata, 49
modesta, 38
MYCOGLAENA, **28**
MYCOPORELLUM, 9, **31**
MYCOPORUM, 9, **31**
myricae, 29
neglecta, **45**, 51
neglecta ssp. occidentalis, **51**
nitida, 42, 46, 50
NORMANDINA, 3
nucula v. heterospora, 50
oblongata, 27
ohiense, 32
oxyspora, 23
parameca, **25**
phaeospora, **36**
PLAGIOCARPA, **34**
PLEUROTREMA, 34
POLYBLASTIOPSIS, 28, **38**
PORINA, 50
punctiformis, 9, **13**
punctiformis v. fallax, 39
pycnocarpum, **31**
PYRENILLIUM, 9
pyrenocarpum, 31
PYRENULA, 19, 34, **42**
quercicola (Mycoglaena), **30**
quercicola (Polyblastiopsis), 39, 40
septemseptata, 34, **37**
sericea, 38
solivagum, 35
sphaeroides, 11, 49
sphinctrinoides, 38
STRIGULA, 9, 43
subcoerulescens, 28
submuriformis, 9, 13, **15**
subpunctiformis, **49**
tenuis, 9, 13, **16**
TOMASELLIA, 48
TRYPETHELIUM, 43, 48
virens, 48
wallrothii, **27**
willeyana, 11, **16**

OLIVER ATKINS FARWELL—A REFLECTION

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There appeared in 1953 a publication by Rogers McVaugh, Stanley A. Cain, and the late Dale J. Hagenah titled: *Farwelliana: An Account of the Life and Botanical Work of Oliver Atkins Farwell, 1867-1944.* This will undoubtedly continue to be the definitive account of one of the state's important early botanists.

During the summer of 1972, while engaged in field work in the Upper Peninsula, we drove through Farwell's hometown of Lake Linden in Houghton County and decided, quite whimsically, to stop by the old post office that Farwell had used. (His box was #265.) After briefly contemplating this still quaint old town and recalling its resident botanist of bygone days we drove on toward a further destination. Aware that we were in "Farwell Country," it later occurred to us to check the Lake Linden telephone directory for any Farwell who might still reside there. We had been told that none were left and that the old family home had been torn down. However, much to our surprise, the directory carried the name of Miss Olive Farwell, who resided at the corner of Front and Sixth Streets. We then decided to pay her a visit.

Upon knocking at the upstairs apartment door, we were greeted by a perfectly charming young lady 91 years of age. Olive Farwell immediately welcomed us and her alert behavior and warm personality bespoke enjoyable moments we were about to share. What follows are some notes derived from three discussions that took place during June, July, and August of 1972. Miss Olive Farwell resides at this old house, which once belonged to the D. D. Brockways, where they lived after retirement from Copper Harbor. It is in this house that Oliver lived after retirement from the drug firm of Parke, Davis & Co. and where for 30 years Olive has lived, following her retirement as an interior decorator, who spent much time in the western United States. She is the youngest and last survivor of eleven children and is the last descendent of her father to bear the Farwell name. Only one grandchild was produced; he is Rudolph Gagg who resides in New Jersey. Olive readily agreed to recount something of the family life and background that helped to mold Oliver Atkins Farwell, the fourth of the eleven children.

Oliver's mother was Charlotte Louise Brockway, daughter of D. D. Brockway, for whom Brockway Mountain Drive in Keweenaw County and Brockway Street in Copper Harbor are named. Oliver's great grandmother was a Howland whose ancesters came to this country on the Mayflower. His father, Oliver Atkins Farwell, senior, was a businessman who made and lost three fortunes, the last of which was in copper. According to Miss Farwell, he, along with John Senter of Eagle River, were the two wealthiest men in the Keweenaw Peninsula. The older Farwell, Oliver's father, was an artistic Bostonian who brought back objêts d'art from all over the world during his

earlier successful business ventures as importer of spices and teas from India. He was 29 years older than his prematurely gray wife, Charlotte Brockway, whom he married in Copper Harbor. At that time, he was 52 and she was 23 years old. Olive was born the day of her father's funeral; he was 70 years of age.

At the time of his father's death in 1881, the future botanist was 13 years of age. He soon became very attached to Frank Elmer Wood, the capable teacher of the one-room schoolhouse at the Cliff Mine location. This was near his childhood place of residence, where he lived along with his siblings, his mother, and his grandparents, the D. D. Brockways.

Mr. Wood's widow, Mary Cokely Wood, died at the age of 99 in Ann Arbor on December 16, 1971. (Some information about her is contained in a note by Bartlett, Asa Gray Bull. N.S. 3: 3-5, 1955.) In a memo sent by her to the late professor Bartlett, she wrote: "...among his pupils was Oliver Farwell. One day my husband announced to the class that the following semester there would be a class in either Bookkeeping or Botany. The pupils were to think it over and the matter would be decided the next day. When Oliver was asked his decision he replied 'I want bookkeeping but my mother says I must take botany.' So Oliver had a six week's course in botany which was all—so I've understood—the systematic teaching of Botany that he ever had."

Oliver wanted to attend the Naval Academy at Annapolis. His teacher, Mr. Wood, introduced him to a U.S. Congressman who recommended him for an appointment at Annapolis. However, his mother refused to finalize the arrangements by signing certain papers for his attendance. She was reluctant because Oliver's grandfather had died at sea, and his father had been almost lost at sea. Following this disappointment, Mr. Wood worked even harder to persuade Oliver to continue his botanical work.

We inquired of Olive during one visit as to how her brother became botanist for the Parke, Davis drug firm in Detroit. She told us that Mr. Hervey Parke, founder of the firm, was business manager of Cliff Mine properties from 1852 to 1863. He was a close friend of the D. D. Brockway family which included one son and four lovely daughters, Charlotte Louise, Delia, Sallie, and Anna. Mr. Parke had a special liking for Charlotte Lousie, Oliver's mother-to-be, but she later married Mr. Farwell, the businessman. Thus it was through these family connections that Mr. Parke would learn of Oliver and his botanical interests, and the job he later offered young Oliver was retained for the rest of his professional life.

After 1881 Oliver's mother was left alone with eleven children, and although she owned some Calumet and Hecla stock, it was of insufficient quantity to insure all family needs. Oliver's father had owned 52 percent interest in Cliff Mine but for him, its second owner (and manager), it was not a long-lived producer of income for the few families it supported.

The family moved to Ypsilanti where the children would have a much better educational opportunity for college. However, the old house in Lake Linden, where the Brockways lived and later rented, has remained in the

family for four generations, and today it is the oldest house left in town. In its back yard stands the last of six red oak trees (*Quercus borealis*) planted by Oliver. The five others were too close to the house and were removed. A fire swept through the town in the late 1800s and, for some strange reason, bypassed the Farwell residence but took neighboring homes of older vintage.

The upstairs apartment in which Miss Olive Farwell now resides has many valuable antiques, including a Chippendale chair made in England and other pieces over 200 years old. Olive showed us a family heirloom—the largest chlorastrolite (greenstone) we have seen.

Oliver's private life was a disappointment, according to his sister. He was twice engaged and wanted to leave an heir, but both girls turned him down, failing to detect a spiritual quality in his life. Oliver's compelling life interest was always his botanical studies. He was not, in any sense, a "socialite." He lived very much with his own thoughts and spent hours of leisure time reading history, autobiographies, science, and poetry. His sister recounts, "I once came home and found him on the living room davenport, still in his hiking outfit, reading poetry—in German." His inclinations toward sociability were often

Oliver A. Farwell, from a photograph in the home of Miss Olive Farwell, Lake Linden, Michigan.

enhanced when there was a good card game in the making, a croquet match, or something cooking that excited his interest, such as a goose roasting. He never drove a car but in the Detroit area would ride a train, e.g., out from Detroit, collect plant specimens all day, placing them in his brief case, and then return at night.

Many of his summers were spent in the old house in Lake Linden, from which many of his private thoughts and observations were set down in writing and published in the obscure Gray Memorial Botanical Association Bulletin (Journal) which served as one of his professional outlets between 1935 and 1942 (see history in Asa Gray Bull. N.S. 1: 3-22. 1952).

One of his papers, written at Lake Linden and dated February 8, 1936, starts out: "Not much botanizing in mid-winter with sub-zero weather and over two feet of snow. Have been overhauling my herbarium this winter which has been in storage for 20 years, and I find a lot of plants I did not know I had collected; or rather had forgotten all about them. But a sight of each recalls the occasion to memory like meeting old and long lost friends. . . ."

In November, 1944, Cranbrook Institute of Science inherited his personal herbarium which contained some 19,000 specimens now on file. Miss Farwell related a story never before told concerning his collection. When the Institute ornithologist, Walter P. Nickell, took a truck to Lake Linden to acquire the gift of the Farwell herbarium, there was no one living at the home to direct the picking up of a chest of Farwell's notes and notebooks, along with the plant specimens. Thus was lost a most important set of data which would have complemented the specimens. Among these data might well have been information pertaining to certain of his dubious Michigan records. Miss Farwell recalls Oliver's red fountain pen often used for notation, but which later mysteriously disappeared one day.

We left Olive on our second visit with some interesting gifts for the Institute. These included the hand lenses used by her brother and certificates of Fellowship from Cranbrook Institute of Science and from the American Geographical Society, as well as his honorary degree of Doctor of Science in botany awarded June 15, 1933, by the colleges of the City of Detroit (later named Wayne State University). We further received a piece of mail dated July 12, 1972, from his ancestral John Howland Society of Woonsocket, R. I. The regular mailing of these pamphlets bearing his name and address was never terminated following his death at Lake Linden on September 18, 1944. The Farwell genealogy dates from the 13th century. However, for Michigan botanists this small vignette would not have occurred without the chance encounter with such a charming and bright lady as Miss Olive Farwell, the last to bear the name.

REFERENCES

Bartlett, H. H. 1954 ["1953"]. "Farwelliana": A review, with notes on the Herbarium and Botanical Library of Parke, Davis and Company and on Ma-Huang. Asa Gray Bull. N.S. 2: 315-321.

Chaput, Donald. 1971. The Cliff: America's First Great Copper Mine. Sequoia Press, Kalamazoo, Michigan. 116 pp.

McVaugh, Rogers, Stanley A. Cain, and Dale H. Hagenah. 1953. Farwelliana: An Account of the Life and Botanical Work of Oliver Atkins Farwell, 1867-1944. Cranbrook Inst. Sci. Bull. 34. 101 pp. (Available for $1.00 from Cranbrook Institute of Science, Bloomfield Hills, Michigan 48013.)

NOTE: On file at Cranbrook are a complete set of Farwell's reprints as well as files indexing his collections by number. The Parke, Davis herbarium and botanical library were donated to the University of Michigan Herbarium, where there is also located a complete set of Farwell's published articles and an index to his published records, by species.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan botany under four categories: A. Maps, Soils, Geology, Climate (new maps and selected bulletins or articles on matters useful to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan—not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (institutions as well as travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

—E. G. V.

A. MAPS, SOILS, GEOLOGY, CLIMATE

Carlson, Richard E. 1971. Lakeshore physiography and use. Limnos 4(2): 3-14. [Includes maps, statistics, and typical photos for U.S. shores of all five Great Lakes (excluding, for some reason, islands); 10 physiographic shore types are defined and shown on the maps, including high and low bluffs, dunes, wetlands, etc.]

Earle, Guy H., Jr. 1972. Soil Survey of Lapeer County, Michigan. U.S. Dep. Agr. 150 pp. + 79 once-folded map plates + 5-page table + 5 folded legends and indexes. $5.75 (Supt. of Documents). [Includes complete 1968 aerial photographic coverage for the county, on a scale of about 4″ to a mile, with boundaries of soil types superimposed. The text and photographic coverage will be invaluable to field botanists in the county.]

Hendrickson, G. E., & C. J. Doonan. 1972. Reconnaissance of the Rifle River, a Cold-Water River in the Northeastern Part of Michigan's Southern Peninsula. U.S. Geol. Surv. Hydrol. Invest. Atlas HA-426. 2 sheets. $1.25. [Maps show width and depth of channel, bed and bank materials, and height of banks and bank vegetation from Selkirk to just north of mouth of Houghton Creek. Additional data on temperature (including tributaries), chemical quality, streamflow, etc.—as in previous publications in this series, noted in Mich. Bot. 11: 43-44. Two large folded sheets in a pocket.]

Holcomb, Sheldon. 1972. Soil Survey of Genesee County, Michigan. U.S. Dep. Agr. 113 pp. + 50 once-folded map plates + 6 folded tables, indexes, and legends. $3.75 (Supt. of Documents). [Includes complete 1964 aerial photographic coverage for the county, on a scale of about 3¼″ to a mile, with boundaries of soil types superimposed. As for all such recent soil surveys, invaluable to the field botanist.]

Kapp, Ronald O., Stephen Bushouse, & Benjamin Foster. 1969. A contribution to the geology and forest history of Beaver Island, Michigan. Proc. Conf. Great Lakes Res. 12: 225-236. [Presents pollen analysis from two cores, with additional data on sediment stratigraphy and postglacial history, including map showing Algonquin and Nipissing beaches. Cf. also paper by King & Hohn under section C below.]

Mettert, Wesley. 1972. Soil Survey of Gladwin County, Michigan. U.S. Dep. Agr. 112 pp. + 62 once-folded map plates + 4-page table + 5 folded legends and indexes. $4.75 (Supt. of Documents). [Includes complete 1968 photographic coverage for the county, on a scale of about 4″ to a mile, with boundaries of soil types superimposed. A useful guide to field workers in the county!]

Pawling, John W. 1972. Terrain regions of the southern peninsula of Michigan. Mich. Academ. 4: 311-323. [Highland and lowland regions, with 10 maps, but these are so poorly reproduced that differences in elevations and relief cannot always be interpreted from the legends.]

Strommen, Norton D. 1968. Michigan Snowfall Statistics; First 1-, 3-, 6-, 12-inch Depths. Mich. Dep. Agr., Mich. Weather Serv. 31 pp. [Includes maps and tables, with elevations of recording stations.]

Strommen, N. D. 1969. Michigan Snow Depths. Mich. Dep. Agr., Mich. Weather Serv. 17 pp. [Includes 3 pages of general information, 10 maps, and table of mean snowfall (by months, and annually) for 130 stations in Michigan, 1931-1960.]

Strommen, N. D., C. van den Brink, & E. H. Kidder. 1969. Meteorological Drought in Michigan. Mich. Agr. Exp. Sta. Res. Rep. 78. 24 pp. [Tables and graphs for 10 general regions in the state.]

(U.S. Geological Survey). The following topographic maps for Michigan have been published by the U.S. Geological Survey, 1200 S. Eads St., Arlington, Virginia 22202, since the previous listing in our January 1972 issue. All are 7½-minute quadrangles (scale of 1:24,000 or about 2½″ to a mile). Maps are supplied with green overprint showing wooded areas unless request is made to the contrary. The price is now $.75 each. Revised maps are marked with an asterisk in the list below; others are new or resurveyed. Following the name of the quadrangle, the county or counties in which it primarily lies are added.

Assumption* [Lenawee + Ohio]
Bentley [Gladwin, Bay]
Birch Run South [Genesee]
Browns Corners [Clare]
Coleman [Gladwin, Midland]
Coleman NE [Gladwin]
Clio [Genesee]
Davison [Genesee]
Denton* [Washtenaw, Wayne]
Durand [Shiawassee, Genesee]
Edenville [Gladwin, Midland]
Edwards [Ogemaw]
Estey [Midland, Gladwin, Bay]
Fayette* [Lenawee + Ohio]
Fenton [Oakland, Genesee]
Flint North [Genesee]
Flint South [Genesee]
Flushing [Genesee]
Gladwin [Gladwin]
Goodrich [Genesee]
Hope [Gladwin, Midland]
Linden [Genesee]
Loomis [Clare, Isabella]
Lyons* [Lenawee + Ohio]
Meredith [Roscommon]
Morenci* [Lenawee + Ohio]
Montrose [Saginaw, Genesee]
New Lothrop [Shiawassee, Genesee]
Northville* [Oakland, Wayne]
Otisville [Genesee]
Redford* [Oakland, Wayne]
Sage Lake [Ogemaw]
Salem* [Oakland, Washtenaw, Wayne]
Secord Lake [Gladwin]
Skeels [Gladwin]
South Branch [Ogemaw]
Sterling NW [Ogemaw]
Swartz Creek [Genesee]
Wagarville [Gladwin]
Walled Lake* [Oakland]
Wooden Shoe Village [Gladwin]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Beard, James B. 1971. Improved Establishment and Maintenance of Roadside Vegetation in Michigan 1963-1970 Final Report. Mich. Agr. Exp. Sta. Res. Rep. 144. 66 pp. [Report on cooperative work with State Highway Department "dedicated to improving the vegetation and environment on Michigan roadsides as well as to assist the personnel within the Michigan State Highway Commission responsible for roadside establishment and maintenance." Deals primarily with seed mixtures on different soils for "rapid, uniform establishment of a vegetative cover."]

Corner, E. J. H. 1970. Supplement to "A Monograph of Clavaria and Allied Genera," Beih. Nova Hedwigia 33. 299 pp. + 4 pl. [*Clavariadelphus sachalinensis* cited from Michigan and *Clavulina amethystinoides* from Gogiebic (sic) Co., Michigan.]

Erickson, John R. 1972. The Moisture Content and Specific Gravity of the Bark and Wood of Northern Pulpwood Species. North Central For. Exp. Sta., U.S. For. Serv. Res. Note NC-141. 3 pp. [Data from aspen, jack pine, red pine, sugar maple, white spruce, and balsam fir in Baraga and Houghton counties.]

Heerwagen, Arnold J. 1971. A Selected Bibliography of Natural Plant Communities in 11 Midwestern States. U.S. Dep. Agr. Misc. Publ. 1205. 30 pp. $.30 (Supt. of Documents). [Lists 742 titles, many of which deal with Michigan, alphabetically by author with no geographic or other index; in addition to published work, a number of masters and doctoral theses are included, especially from the University of Wisconsin —apparently only one from any Michigan institution.]

Hepting, George H. 1971. Diseases of Forest and Shade Trees of the United States. U.S. Dep. Agr., For. Serv., Agr. Handb. 386. 658 pp. $4.00 (Supt. of Documents). [After scarcely two pages of introduction, this consists of a listing of trees (alphabetical by scientific names) with brief general remarks and itemization of reported diseases, keyed to a 1669-title bibliography. An enormous compendium—with occasional references to conditions reported in Michigan. It is a bit surprising to read that on black spruce dwarf mistletoe is "caused by" *Arceuthobium pusillum*—which *is* dwarf mistletoe.]

Hultén, Eric. 1971. The Circumpolar Plants. II Dicotyledons. Sv. Vet-akad. Handl. IV. 13(1). 463 pp. Sw. kr. 175 (= ±$34.00). [This eagerly awaited completion of a mammoth mapping, bibliographic, and interpretive project by the world's leading authority on boreal floras includes 301 maps showing distribution, often in surprising detail, for species found around the pole in northern latitudes—including many Michigan plants. The lifetime of wisdom in the accompanying discussion will help local taxonomists everywhere in the circumpolar area. We have apparently failed previously to call attention to Part I (Vascular Cryptogams, Conifers, Monocotyledons) of this great work (Sv. Vet-akad. Handl. IV. 8(5). 275 pp. 1962, 2nd ed. 1964. Sw. kr. 110 (= ±$21.40).)]

Kuo, P. C., et al. 1971. Improving Michigan's White Pine. Mich. Agr. Exp. Sta. Res. Rep. 149. 12 pp. [General introduction on white pine and results of a 9-year progeny test including open-pollinated offspring of 123 native Michigan trees.]

Pringle, James S. 1970. The Trilliums of Ontario. Royal Bot. Gard. (Hamilton) Tech. Bull. 5. 30 pp. [Much general and descriptive information on four species, with occasional references to Michigan; no key.]

Shetron, Stephen G. n.d. [1972?]. Site Index Curves for Sugar Maple in Northern Lower Michigan. Mich. Tech. Univ., Ford For. Center Res. Note 6. 8 pp. [Study on five soil series.]

Skog, Roy E., Melvin R. Koelling, & Lester E. Bell. 1971. Forests and the Environment. Mich. St. Univ. Ext. Serv. Bull. E-716. 15 pp. [General discussion of forest ecosystems, beneficial effects of forests, forest influences on soil and water; almost no specific reference to Michigan, but local origin of the bulletin implies local basis for text and photos.]

Smith, Alexander H. 1972. The North American Species of Psathyrella. Mem. N. Y. Bot. Gard. 24. 633 pp. $35.00 [Ranges from collecting techniques to the expected fine illustrations, with 414 species fully described in between. Many of these are cited from Michigan, usually without further locality data except for the types of numerous new taxa.]

Voss, Edward G. 1972. Michigan Flora Part I. Gymnosperms and Monocots. Cranbrook Inst. Sci. Bull. 55. 488 pp., 9 col. pl. $7.50. [Includes keys, a county distribution map for each species (723), 345 line drawings, and 46 color photos; see review in previous issue, pp. 213-214.]

C. JOURNAL ARTICLES

Allen, Harold L. 1971. Primary productivity, chemo-organotrophy, and nutritional interactions of epiphytic algae and bacteria on macrophytes in the littoral of a lake. Ecol. Monogr. 41: 97-127. [Study in Lawrence Lake, Barry Co.]

Auclair, Allan N., & F. Glenn Goff. 1971. Diversity relations of upland forests in the western Great Lakes area. Am. Midl. Nat. 85: 499-528. [No specific references to Michigan, but analysis based on data assembled from stands including forests of "northern Michigan."]

Auclair, Allan N. 1972. Comparative ecology of the orchids Aplectrum hyemale and Orchis spectabilis. Bull. Torrey Bot. Club 99: 1-10. [Distribution maps include Michigan localities, but are so severely reduced that dots in northern part of the state are nearly unrecognizable.]

Dancik, Bruce P., & Burton V. Barnes. 1972. Natural variation and hybridization of yellow birch and bog birch in southeastern Michigan. Silvae Geneticae 21: 1-9. [Study of a natural population at Walsh Lake, Washtenaw Co.]

Davies, William. 1971. The phytopsammon of a sandy beach transect. Am. Midl. Nat. 86: 292-308. [Study of beach sand and its algae at Duck Lake, Oakland Co.]

Dodd, James L. 1972. The genus Clavicorona. Mycologia 64: 737-773. [*C. taxophila* and *C. pyxidata* cited from Michigan localities.]

Gillis, William T. 1971. The systematics and ecology of poison-ivy and the poison-oaks (Toxicodendron, Anacardiaceae). Rhodora 73: 72-159; 161-237; 370-443; 465-540. [Distribution maps include Michigan dots for *T. radicans* ssp. *negundo* in southern two-thirds of the Lower Peninsula and *T. rydbergii* farther north (except along Great Lakes shores southward); numerous representative specimens are cited from the state, and hybrids between these two taxa are cited from four Michigan counties. Some of the ecological and life history observations also include Michigan data.]

Gould, F. W., M. A. Ali, & D. E. Fairbrothers. 1972. A revision of Echinochloa in the United States. Am. Midl. Nat. 87: 36-59. [Distribution maps include Michigan dots for *E. muricata* and *E. walteri,* and one "representative" Michigan specimen of *E. crusgalli* (not mapped) is cited.]

Hickok, L. G., & J. C. Anway. 1972. A morphological and chemical analysis of geographical variation in Tilia L. of eastern North America. Brittonia 24: 2-8. [Map indicates 7 Michigan collection sites for *T. americana,* the only species recognized in eastern North America.]

Hill, Royce. 1972. Comparative patterns of CO_2 exchange of three fern species of southeastern Michigan. Mich. Academ. 4: 303-310. [Study involving *Thelypteris palustris, Woodwardia virginica,* and *Adiantum pedatum* in Washtenaw Co.]

Hooper, G. R., F. W. Case, Jr., & R. Myers. 1971. Mycoplasma-like bodies associated with a flower greening disorder of a wild flower, Trillium grandiflorum. Pl. Disease Reporter 55: 1108-1110. [Mentions colonies in Tuscola and Montcalm counties, but not the origin of the material actually studied. Suggests that the pathological nature of the "sport" trilliums indicates that they not be formally named and that they not be cultivated, lest the disease spread excessively.]

Jones, Cynthia L., & Ronald O. Kapp. 1972. Relationship of Bay County Michigan presettlement forest patterns to Indian cultures. Mich. Academ. 5: 17-28. [Vegetational data from pollen profile from Tobico Marsh and original land survey records for half of Bay County's townships.]

King, Donna K., & Matthew H. Hohn. 1972. Geological succession in Barney's Lake, Beaver Island, Michigan and its effect on the fossil diatom flora. Mich. Academ. 4: 499-510. [Correlations with Algonquin, Chippewa, Nipissing, and Algoma levels; cf. also paper by Kapp, Bushouse, & Foster under section A above.]

Robbins, Steven G., & Matthew H. Hohn. 1972. Effects of post-glacial lakes on Fox Lake, Beaver Island, Michigan, based on analysis of the fossil diatom flora. Mich. Academ. 4: 349-358. [See also paper by Kapp, Bushouse, & Foster in section A, above.]

Settle, Wilbur J., & T. Richard Fisher. 1970. The varieties of Silphium integrifolium. Rhodora 72: 536-543. [Map shows var. *integrifolium* in the southwestern Lower Peninsula.]

Shaffer, Robert L. 1972. North American Russulas of the subsection Foetentinae. Mycologia 64: 1008-1053. [Eight of the 10 species are cited from Michigan localities.]

Shelton, Napier. 1970. Lincoln's sparrows at the Minden City State Game Area. Jack-Pine Warbler 48: 94-96. [Includes a paragraph describing the vegetation of the large bog which comprises this area, in Sanilac County.]

Stuckey, Ronald L. 1972. Taxonomy and distribution of the genus Rorippa (Cruciferae) in North America. Sida 4: 279-430. [Maps include Michigan distribution for three varieties and one hybrid in *R. palustris* and for *R. sylvestris.* Further local discussion under *R. palustris.* A monograph with keys and full descriptions.]

Thieret, John W. 1971. The genera of Orobanchaceae in the southeastern United States. Jour. Arnold Arb. 42: 404-434. [Distribution map for *Epifagus virginiana* includes dots for Michigan localities.]

Thompson, Paul W. 1972. North shore dunes windswept Lake Michigan dunescape. Nature Conservancy News 22(1): 16. [Brief description of physiography and vegetation of 50-acre preserve north of Grand Haven.]

Wood, Carroll E., Jr. 1971. Some floristic relationships between the southern Appalachians and western North America. Pp. 331-404 in The Distributional History of the Biota of the Southern Appalachians. Part II. Flora (Perry C. Holt, ed.). Virginia Polytechnic Inst. Res. Div. Monogr. 2. [Distribution maps, mostly generalized, for a number of species show occurrence in Michigan.]

Wright, Jonathan W. 1972. Genetic variation patterns in Michigan's native trees. Mich. Academ. 5: 61-69. [Concludes that Straits of Mackinac has constituted a barrier to pollen and seed, resulting in fast-growing Upper Peninsula races and slower growing Lower Peninsula races in at least four species; species at southern edge of their range in Michigan grow faster here than farther north, while species at northern edge of their range here often do less well. Except for black and sugar maples, hybridization—even in oaks—is uncommon in the state.]

D. HISTORY, BIOGRAPHY, EXPLORATION

Chaput, Donald. 1971. The Cliff: America's First Great Copper Mine. Sequoia Press, Kalamazoo. 116 pp. $12.00. [Copiously illustrated history of copper mining, with special reference to the mine with which is associated the name of Farwell (see p. 69 in this issue—O. A. Farwell, Jr., collected copiously in the vicinity of Cliff Mine, or Clifton). The senior O. A. Farwell is mentioned and two of his daughters, but not the botanical son (nor the only surviving daughter).]

Correll, Donovan S. 1971. Lloyd Herbert Shinners—A Portrait. Brittonia 23: 101-104. [See also Mahler, below. Dr. Shinners collected in Michigan in 1952.]

(Anon.). 1971. Dale J. Hagenah 1908-1971. Cranbrook Inst. Sci. News Letter 41: 29. [Brief obituary notice of curator of Cranbrook herbarium; for fuller account, see Mich. Bot. 11: 60-66. 1972.]

Halpern, Jeanne W. 1970. Research at the Matthaei Botanical Gardens. Research News, Off. Res. Adm., Univ. Mich. 20(8). 11 pp. [Some projects and activities at the U. of M. gardens.]

Halpern, Jeanne W. 1971. The University Herbarium 50th Anniversary. Research News, Off. Res. Adm., Univ. Mich. 21(10-11). 19 pp. [Historical notes and some projects and operations of the U. of M. herbarium.]

Halpern, Jeanne W. 1972. Probing the Delicate Balance: Research at the Biological Station. Research News, Off. Res. Adm., Univ. Mich. 23(4). 15 pp. [Historical notes and some new directions in research at the U. of M. Biological Station.]

Hanna, Murray. 1971. Regulatory nematology in Michigan. Mich. Academ. 4: 217-225. [Historical notes on plant disease control in Michigan, with full-page photo of the late E. A. Bessey.]

Jackman, Sydney W., & John F. Freeman (eds.). 1969. American Voyageur. The Journal of David Bates Douglass. Northern Mich. Univ. Press, Marquette. 128 pp. $4.25. [Journal of the topographer and botanist with the Cass Expedition of 1820, including many botanical observations. See Review in Mich. Bot. 11: 121-122. 1972.]

Lampe, Lois (chairman, necrology committee). 1971. E(mma) Lucy Braun. Ohio Jour. Sci. 71: 247-248. [Obituary notice of the celebrated plant ecologist (1889-1971) whose great work on the deciduous forest included study of Michigan stands. A biographical sketch and full bibliography will appear in the next issue of Mich. Bot.]

Mahler, Wm. F. 1971. Lloyd Herbert Shinners 1918-1971. Sida 4: 228-231. [A brief and sympathetic biography; see also Correll, above.]

Nuttall, Thomas. 1971. The Genera of North American Plants . . . (Facsimile of the 1818 edition). Hafner Publ. Co., New York. 2 vols. $32.50. [A facsimile reprint, with generously wide margins, of the first published work to include reports of plants in Michigan, including new species such as *Iris lacustris* (see Mich. Flora pp. 10-11). An introduction by Joseph Ewan (pp. ix-xxxvii plus reproduction of a page from the original manuscript) increases the usefulness of the reprint. Introduction concludes with a gazeteer, a pre-1818 chronology, and references; gazeteer lists St. Helena Island in Emmet Co. rather than correctly in Mackinac Co. (correct for Bois Blanc Is.).]

Voss, Edward G. 1972. The state of things: Contributions of the plant taxonomist in Michigan. Mich. Academ. 5: 1-7. [Some of the uses, real and potential, of taxonomy to the citizens and welfare of the state, as presented at a symposium on "Contributions of Botanists in Michigan."]

Weatherwax, Paul. 1971. Charles Clemon Deam: Hoosier Botanist. Indiana Mag. History 67: 197-267. [A readable and rambling account of Indiana's famed botanist, who with his wife did a little collecting in Michigan—although this account includes no data on collecting itineraries.]

Publications of Interest

GEOLOGY, SOILS, AND HYDROGEOLOGY OF VOLO BOG AND VICINITY, LAKE COUNTY, ILLINOIS. By Murray R. McComas, John P. Kempton, & Kenneth C. Hinkley. Illinois State Geological Survey Environmental Geology Notes No. 57. 1972. 27 pp. [processed]. This report summarizes principal findings of a study to determine possible effects that construction of subdivisions, shopping centers, and a golf course in and near the basin of a sphagnum bog might have on the hydrologic regime and overall ecological balance of the bog. A well documented background report on the nature of the bog setting, as well as a contribution toward defense of a natural area from surrounding "development."

PRAIRIE GRASSES Identified and Described by Vegetative Characters. By Keith F. Best, Jan Looman, & J. Baden Campbell. Canada Dep. Agr. Publ. 1413. 1971. 239 pp. $2.75 (from Information Canada, Ottawa). An expanded revision of an earlier publication on identification of native and naturalized grasses by their vegetative characters. Includes key, illustrations, and descriptive notes. Almost three-fourths of the 104 species included occur in Michigan.

Editorial Notes

As announced in the previous two issues, the price of back numbers is now uniform, as stated on the inside front cover.

The October number (Vol. 11, No. 4) was mailed October 27, 1972.

COMING ATTRACTIONS: This issue and the preceding have been, in a real sense, bonuses to our members and subscribers, since costs of the long articles filling them have been subsidized. Many shorter articles await publication and will allow for large March and May issues. Lead article in the March issue will be a biographical sketch with complete bibliography of the late Dr. E. Lucy Braun, authority on the flora of Ohio and the deciduous forests of eastern North America, a noted conservationist and ecologist. Other articles to appear soon include ones on the bluebead lily, *Clintonia borealis*; moss chromosomes in the Douglas Lake region; lichen flora of elm bark; golden brown algae in Michigan; two species of false morel; scanning electron microscopy of a liverwort spore and elater—and other studies in mosses, fungi, and higher plants.

Plan now to attend the 1973 campout of the Michigan Botanical Club, to be held Memorial Day weekend at Northern Michigan University, Marquette.

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(Act of August 12, 1970: Section 3685, Title 39, United States Code)

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CONTENTS

The Corticolous Pyrenolichens of the Great Lakes Region
Richard C. Harris 3

Oliver Atkins Farwell—A Reflection
James R. Wells & Paul W. Thompson 69

Michigan Plants in Print 73

Publications of Interest 78

Editorial Notes 79

(On the cover: Eopyrenula leucoplaca, *a crustose lichen with white thallus and numerous black ascocarps, on the bark of sugar maple,* Acer saccharum, *×1¾. Photo by C. J. Hibbard (no. 5444) for Bruce Fink, near Duluth, Minnesota, September 6, 1902. See p. 20.)*

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Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow current style and the suggestions in "Information for Authors" (Vol. 12, p. 142; copies available from the editor).

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E. LUCY BRAUN (1889-1971), OUTSTANDING BOTANIST AND CONSERVATIONIST: A BIOGRAPHICAL SKETCH, WITH BIBLIOGRAPHY[1]

Ronald L. Stuckey
College of Biological Sciences,
The Ohio State University, Columbus

In March 1971, the botanical community lost a most respected colleague, indefatigable worker, and original thinker in the fields of plant ecology, vascular plant taxonomy, plant geography, and conservation. During an active life spanning 82 years, E. Lucy Braun gathered facts from the field, garden, and laboratory which were used as a basis for stimulating ideas and challenging opinions–many of which were put together in over 180 publications that appeared as four books and in 20 scientific and popular journals. Dr. Braun was one of the truly dedicated pioneer ecologists of the first half of the 20th century. Her work coincided with the time when the field of plant ecology was becoming recognized as a scientific discipline. Truly her work was instrumental in the development of that discipline.

Furthermore, during Dr. Braun's lifetime, mankind in this country became aware that wilderness areas and nature preserves should be set aside as part of our natural heritage. Here, too, she was in the forefront of the fight to preserve remnants of the natural environment, both as an individual and working through major organizations. Her contributions to botany and conservation are enumerated here as a timely reminder of what one person has accomplished. The evaluations and opinions of her work expressed in this paper are primarily taken from reviews published by her colleagues and from impressions I have gained talking with her and with some of her associates. Future historians of science should recognize Dr. Braun's achievements as milestones in the history of botanical science for the 20th century.

Born in Cincinnati, Ohio, 19 April 1889, Emma Lucy Braun spent her entire life in Cincinnati, where she was educated in the Cincinnati schools, received her undergraduate and graduate education from the University of Cincinnati, and was a professor in the Botany Department of the University of Cincinnati. Miss Braun's early interest in the natural world, like that of her older sister, Annette (an entomologist), who shared in all her work, was fostered by her parents who took the girls to the woods and identified wild flowers. Their mother was especially interested in botany and had compiled a small herbarium (Annette Braun, 1972). The two sisters lived together at the same residence on a two-acre lot in Mount Washington (5956 Salem Road) in suburban Cincinnati. Their home and garden, surrounded by mostly natural

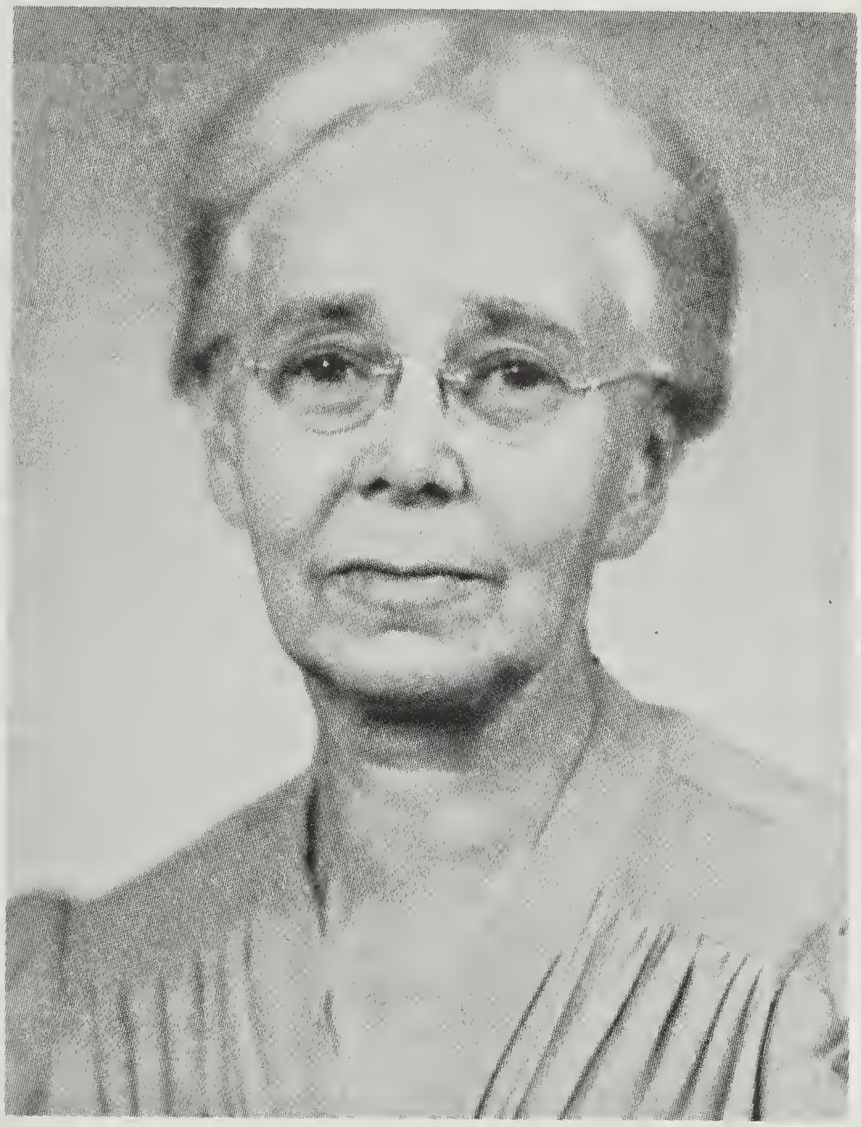
[1]Contribution from the Department of Botany (Paper No. 815) and Herbarium, The Ohio State University.

undisturbed woods, contained an area, both inside and outside, that they called the "science wing," which served as their laboratory. Their garden was, in fact, an experimental garden, where many rare and unusual plants were grown for closer observation and study. Among some of the rare transplanted wild flowers were box huckleberry (*Gaylussacia brachycera*), Cumberland azalea (*Rhododendron cumberlandense*), nodding mandarin (*Disporum maculatum*), Allegheny-spurge (*Pachysandra procumbens*), and stoneroot (*Micheliella verticillata*), to mention a few (Annette Braun, 1972). Lucy's personal herbarium, seen by very few, was also close at hand on the second floor in the house. Her herbarium of 11,891 specimens was presented to the United States National Museum shortly before her death (Annette Braun, 1972).

Beginning in 1915, Dr. Braun made 13 trips to the western United States, five of them to the Pacific Coast. From 1934 to 1963, she drove her own car on these western trips. In her younger days, no road, even if almost invisible, was too poor to tackle. On all of these trips, she made observations on the vegetation and prepared herbarium specimens (Annette Braun, 1972). These observations in western United States provided information for some of her popular articles that appeared in the magazine, *Wild Flower.* Most of her field work supporting her scientific publications, however, was concentrated in the eastern deciduous forest, primarily in southwestern Ohio and the mountains of eastern Kentucky.

Several thousand color slides, both of western and eastern regions, attested to her skill as a photographer; especially noteworthy were those of the Grand Canyon, Crater Lake, and the Olympic Peninsula, Colorado, Arizona, and the Canadian Rockies of the West. A great many slides were taken in the Great Smokies, as well as in many other eastern localities, ranging from the Gaspé Peninsula to Florida (Annette Braun, 1972). Some of these slides have appeared as black and white prints in several of her scientific publications. Slides were used in her lectures; an example was one entitled, "Scenery and Flora of the Northwest," given 11 January 1923 in the Cincinnati Wild Flower Preservation Society. It was reported as "A travel lecture of great beauty and interest, embracing the Northwest flora and ecological features of the ascending slopes and levels of Crystal Ridge of the Olympic Mountains. Exquisitely colored slides were shown" (Anonymous, 1924b).

At the University of Cincinnati, Miss Braun received the B.A. in 1910, the M.A. in geology in 1912, and the Ph.D. in botany in 1914. She was an assistant in botany (1914-1917), instructor in botany (1917-1923), assistant professor of botany (1923-1927), associate professor of botany (1927-1946), professor of plant ecology (1946-1948), and emerita professor of plant ecology (1948-1971). Early retirement from teaching allowed her to conduct research in areas of special interest that resulted in the publication of three outstanding books and several major papers during her years as emerita professor. Field work and writing continued nearly to the very end of her life, when she passed away 5 March 1971, after an illness of several months.



Dr. E. Lucy Braun (photograph taken in 1950).

A list of obituaries and biographical sketches known to have appeared to date are grouped together as the first section of "References Cited" following Dr. Braun's bibliography near the end of this paper (Anonymous, 1971a, b, c; Fulford, Dreyer, & Durrell, 1972; Lampe, 1971). Cited documentation may be found in one or the other sections under "References Cited." References to book reviews are listed under the book reviewed in Dr. Braun's bibliography.

CONTRIBUTIONS TO PLANT ECOLOGY

Dr. Braun's early scientific contributions were made in the young and developing field of plant ecology, particularly in forest ecology. She published on the physiographic ecology of the Cincinnati region (1916), the vegetation of conglomerate rocks of the Cincinnati region (1917), the vegetation of the Mineral Springs region of Adams County (1928), the forests of the Illinoian

drift plains of southwestern Ohio (1932), the undifferentiated deciduous forest climax and the association-segregate (1935), the vegetation of Pine Mountain, Kentucky (1935), forests of the Illinoian Till Plain of southwestern Ohio (1936), deciduous forest climaxes (1938), an ecological transect of Black Mountain, Kentucky (1940), and forests of the Cumberland Mountains (1942). Her studies in these subjects and areas formed the basis of her theory of the association-segregate, and the stimulus for writing a monumental book, *Deciduous Forests of Eastern North America.* Published in 1950, this book soon went out of print and was reproduced in facsimile editions in 1964 and 1967. Another facsimile reprinting of 500 copies appeared in 1972 (Annette Braun, 1972). According to the book's preface (p. vii), the publication was based "on some 25 years of field study throughout the deciduous forest involving in the last 12 or 15 years over 65,000 miles of travel, on many years of familiarity with the deciduous forest as a whole, and on intimate association with the study of parts of this forest." Her stated purpose (p. vii) was "to give a broad and coordinated account of the entire deciduous forest—a comprehensive view which may make possible the better understanding of fragments of forest and give a setting for past and future local and detailed studies."

Deciduous Forests received many reviews, all extremely favorable, pointing out the book's use and importance in plant ecology, as well as in related fields such as soil science, silviculture, forestry, conservation, plant geography, animal ecology, and entomology. Pauley (1952) noted the work to be "of interest and value to ecologists and foresters as well as less specialized professional botanists and botanical hobbyists." Viewed from the other side of the world, Conway (1951) spoke of it as a book with the advantage of a "continental outlook," a book with "an objective description of a large number of forests with as much factual detail as a book of its size can contain," a book "to browse in at leisure, a little at a time."

The more extensive reviews of Smith (1951), Fosberg (1951), Raup (1952), and Dansereau (1952), analyzed her treatise in considerable detail. Smith (1951, p. 373-374) stated that

> the book is a stimulating one which is bound to arouse controversy.... There is not likely to be major disagreement over the masterly analysis of the distribution of original forest types, but the question of development of that distribution will produce as many interpretations as interpreters. Dr. Braun has placed great stress on the importance of geologic processes involving millions of years in molding the development of the forests of unglaciated regions. It is her contention that the forests of these regions have remained exceedingly stable. Although she has marshalled her evidence well there are many who will prefer to believe that conditions of soil and climate prevailing in more recent times determine the present distribution of forest types.

Fosberg (1951, p. 67) wrote:

> No one will be likely to question that, as to subject matter, Lucy Braun's knowledge of the Eastern deciduous forest is unequaled. Indeed, from this point of view the book is almost encyclopedic. She describes, from wide field acquaintance, the forests in every section, reconstructing them as they were before ax, fire, and chestnut blight. The geographer, as well as the forester, botanist, and ecologist, will

regard this as the basic work of reference on the condition of the continent before the advent of man. Special attention is not given to the results of man's activities, but the reader is reminded of them. A feature that is especially good is the presentation in tabular form of the composition and abundance of trees in individual stands of forest in all regions. A type of table is used that makes grasp and comparison easy.

. . .

The interpretation of the deciduous forest in terms of its existing remnants, historical and fossil records, dynamic physiography, and geological history is an outstanding accomplishment. The author draws freely on the work and opinions of others, as acknowledged in the extensive bibliography and innumerable text references to it, but her final interpretation is her own, and will doubtless endure very well as new knowledge accumulates.

Her writing is clear and easy reading, though perhaps not brilliant. Compared with that of many of her ecological colleagues, it may do a good deal toward making ecology a more popular and better understood science.

. . .

In over-all evaluation of this book, one can say that it is a definitive work, and that it has reached a level of excellence seldom or never before attained in American ecology or vegetation science, at least in any work of comparable importance. It may be rather too comprehensive to be used as a text in any but the most advanced courses, but from now on it will unquestionably be the standard reference on the vegetation of eastern North America. Its distinguished author is to be congratulated and thanked.

Raup (1952, p. 306-307) analyzed professor Braun's philosophy:

Dr. Braun's basic philosophy of plant geography is derived in large measure from the ideas of vegetational history and development outlined by Cowles. Nevertheless she has manifested a large amount of divergence. Her training and experience in geology and physiography appear to have been far more extensive than is the case for most contemporary plant ecologists and plant geographers. While Clements and others were enlarging the theory of purely biological succession, she was more preoccupied with the history of vegetation as related to the development of land forms. Of equal or greater significance for the production of the present volume has been her divergence into the field of floristic geography. Here she has fallen heir to a vast amount of information and suggestion that has scarcely been touched by most ecologists. Not only has she used this material effectively, but she has made notable additions to it in her own right. Further, not content with existing data on the distribution of species, she has seen and utilized the contributions now being made by modern genetics to the geography of plants. With these divergences she has made an immense contribution, not merely to methodology, but to the breadth and depth of the philosophy of geographic botany.

A statement from Dansereau (1952, p. 332) provides a summary:

This book should offer a number of investigators a fresh opportunity for sharpening their own views on ecological and evolutionary situations, especially in their dynamic aspect.

A detailed ecological analysis of the vegetation of a given locality or local area was Dr. Braun's approach in many of her studies. Her last major study, ". . . The Vegetation of Fort Hill State Memorial . . ." (1969) illustrated this technique well. As Buell (1970) wrote in his review, the study "is a similar graphic analysis of the vegetation to those she presented in some of her earlier papers—for example her study of Black Mountain in 1940 and of Pine Mountain in 1935 with their pictorial transects up and down the

slopes. . . ." Aside from *Deciduous Forests,* Dr. Braun's major ecological studies appeared in five journals: *Ecology, Ecological Monographs, Ohio Journal of Science, Bulletin of the Ohio Biological Survey,* and the *American Midland Naturalist.* Well documented with charts, graphs, maps, tables, and pictures, her studies will be of value to botanists, ecologists, and naturalists for years to come as ecological changes in the deciduous forest are evaluated.

CONTRIBUTIONS TO FLORISTICS AND TAXONOMY

Coupled with her vegetational and ecological studies, Dr. Braun contributed extensively in the field of floristics and taxonomy of vascular plants. Her study of the flora of the Cincinnati area in 1920's and 1930's was compared with the flora a hundred years earlier based on the collections of Thomas G. Lea. The paper, "The Lea Herbarium and the flora of Cincinnati" (1934), was one of the first of this type in this country and certainly a model paper for comparing the changes in a given flora over a span of time. Since this publication, no flora of the Cincinnati area has been prepared. Another early publication was *A Key to the Deciduous Trees of Ohio* . . . (1937). In the 1930's and 1940's, Dr. Braun did extensive field work in southwestern Ohio and eastern Kentucky which resulted in (1) a series of six publications in *Castanea* entitled "Notes on Kentucky Plants" (1936, 1939, 1941, 1942); (2) several papers published in *Rhodora* on plants new to science (see list below), all from Kentucky (1940, 1942, 1943); (3) short notes published in *Rhodora* and *Castanea* on the morphology, habitats, and/or geographical distribution of specific species of flowering plants (*Satureja glabella, Silphium incisum, Solidago shortii, Pachystima canbyi, Arabis perstellata, Polemonium reptans,* and *Dentaria laciniata*) in Ohio and/or Kentucky (1940, 1941, 1956, 1957); and (4) *An Annotated Catalog of Spermatophytes of Kentucky* (1943).

Dr. Braun's work in floristic and taxonomic botany, however, did not end with the above-described studies. With these contributions as a foundation and the ever-determined desire to continue advancing knowledge of the flora, she organized in 1951, within the Ohio Academy of Science, an Ohio Flora Committee, with the objective of preparing a comprehensive "Vascular Flora of Ohio" (Braun, 1952). Serving as chairman of the committee for seven years, Dr. Braun, in her retirement from the University, moved the work of the Flora Project ahead, resulting in two books, *The Woody Plants of Ohio* . . .(1961, facsimile edition 1969) and *The Monocotyledoneae [of Ohio]* . . . (1967). For both books, reviews were highly favorable, mainly pointing out the major features–informative introduction with ecological, climatic, and geological supporting data; workable dichotomous keys; pertinent comments on morphology, habitats, and distribution of most taxa; excellent, well-arranged line drawings from fresh specimens; county dot-distribution maps documented by specimens; and a good glossary (in the *Woody Plants* book). These two scholarly publications contained much original information and were considered by reviewers to be of great value to both amateur and professional naturalists and field botanists. Bush (1962) labeled the *Woody Plants*

> A meticulous, thoroughly scientific presentation of the vascular flora of the Midwestern region. The terminology is technical, the illustrations black-and-white, and the information close to definitive. A serious reference work.

Evers (1961) stated, "It is the kind of book which may well get students interested in the identification of plants. Dr. Braun has done it again!" For *The Monocotyledoneae,* Voss (1967a) wrote:

> The whole book sparkles with a freshness which could not come from merely copying the work of others. As one might expect from its distinguished author, who in her 79th year continues to be one of Ohio's most ardent field botanists, this flora speaks with particular authority in its ecological notes; . . .

Svenson (1969) referred to the work as "A Model Flora. . . ."

Dr. Braun's field work in floristics and taxonomy in southern Ohio and eastern Kentucky is amply documented by specimens deposited in the herbaria of the University of Cincinnati, The Ohio State University, Gray Herbarium of Harvard University, the New York Botanical Garden, and the United States National Museum (Smithsonian Institution). The latter houses her personal herbarium. Those plants described by or named for Dr. Braun are listed below.

PLANTS NAMED AND DESCRIBED BY E. LUCY BRAUN

(Type localities all from Kentucky, except for the fern, ×*Asplenosorus inexpectatus,* which is from Adams County, Ohio)

Arabis perstellata E. L. Braun, Rhodora 42: 47-49. 1940.

×*Asplenosorus inexpectatus* E. L. Braun in Friesner, Butler Univ. Bot. Stud. 4: 154. 1940. (*Asplenium cryptolepis* [Fern.] × *Camptosorus rhizophyllus* [(L.) Link] described by E. L. Braun, Am. Fern Jour. 29: 133. 1939).

Cassia hebecarpa Fern. var. *longipila* E. L. Braun, Rhodora 42: 49-50. 1940.

Draba ramosissima Desv. var. *glabrifolia* E. L. Braun, Rhodora 42: 49. 1940.

Eupatorium deltoides E. L. Braun, Rhodora 42: 50-51. 1940.

Polemonium reptans L. var. *villosum* E. L. Braun, Rhodora 42: 50. 1940.

Rhododendron cumberlandense E. L. Braun, Rhodora 43: 33-35. 1941.

Solidago albopilosa E. L. Braun, Rhodora 44: 2-3. 1942.

Solidago rigida L. var. *glabrata* E. L. Braun, Rhodora 44: 3-4. 1942.

PLANTS NAMED FOR E. LUCY BRAUN

Erigeron pulchellus Michx. var. *Brauniae* Fernald, Rhodora 38: 235. 1936.

Eupatorium Luciae-Brauniae Fernald, Rhodora 44: 463. 1942.

Silphium terebinthinaceum Jacq. var. *Lucy-Brauniae* Steyermark, Rhodora 53: 133-135. 1951.

CONTRIBUTIONS TO PHYTOGEOGRAPHY

Dr. Braun's ecological, floristic, and taxonomic studies conducted in the field naturally led into the study of plant distribution or plant geography. This discipline of phytogeography, based on a synthesis of data and ideas, was continually emphasized throughout most of Dr. Braun's journal publications and books. Information as to where and explanations (sometimes tentative) as

to why a particular species or a floristic element has a given distribution pattern were thoroughly discussed. One of her early articles, "Where and Why," in *Wild Flower* (1924) was a beginning toward this direction of thinking.

With her early interest in the deciduous forest, she developed the theory that the southern Appalachians were the center of survival (she used the term "refuge") during the Pleistocene and dispersal of the deciduous forest communities. From this center she travelled in all directions and collected data to substantiate this interpretation. Several papers dealt specifically with the geographical relationships of this flora. She published on the composition and source of the flora of the Cincinnati region (1921), glacial and post-glacial migrations indicated by relic colonies of southern Ohio (1928), affinities of the flora of the Illinoian Till Plain of southwestern Ohio (1935), a remarkable colony of coastal plain plants on the Cumberland Plateau and Cumberland Mountains in Kentucky (1937), some relationships of the flora of the Cumberland Plateau and Cumberland Mountains in Kentucky (1937), and plant distribution in relation to the glacial boundary (1951). Her *Deciduous Forests,* too, was a phytogeographical analysis, as well as an analysis of the forest vegetation and forest ecology. Raup (1952) extolled the book's virtues from the phytogeographic point of view as quoted earlier. Her knowledge of the phytogeography of unglaciated eastern United States culminated in an extensive analytical-summary, "The phytogeography of unglaciated eastern United States and its interpretation," published in the *Botanical Review* (1955).

Ideas pertaining to the distributional history of the eastern deciduous forest communities were not always in agreement. Edward S. Deevey, Jr. (1949) proclaimed the theory that during the Pleistocene, under cooler climatic conditions, plants of the northern coniferous forest community migrated as far south as Texas and Louisiana and the typical temperate deciduous forest species were pushed south of the Rio Grande into Mexico and deep into peninsular Florida, thereby presenting a picture of an extraordinary intermingling of boreal, temperate, and subtropical floristic elements along the Gulf Coast and inland into Mexico. His evidence was limited primarily to a pollen record from a Texas bog and macrofossil remains in Louisiana. Deevey's theory also proclaimed a belt of tundra vegetation along the glacial ice front in the center of the continent.

By marshalling evidence from the pollen and macrofossil record throughout eastern United States; by learning an accurate picture of the present distribution pattern of each species; by studying the environmental requirements of the plants—habitat, soil, moisture, day-night relationships for flowering, temperature, biotype variability, successional behavior, chromosome situations, physiological tolerances, rates of evolution; and by considering soil-freezing phenomena, climatic and microclimatic studies, physiographic conditions, topographic differences, and geological evidence, Dr. Braun argued vigorously and pointedly against the Deevey theory. These arguments were discussed in detail in her papers on "Plant distribution in relation to the

glacial boundary" (1951) and in "The phytogeography of unglaciated eastern United States and its interpretation" (1955). Her conclusions were summarized in the former paper (p. 145) where she believed (1) " that the deciduous forest zone, although narrowed, maintained itself on the Appalachian Plateaus in southern Ohio and Kentucky while glaciers extended southward in Ohio. Most of its species can endure temperature extremes far greater than those in this area today." (2) "that during the glacial epochs, some species now showing a spotty distribution near the glacial boundary may have persisted in local favorable habitats." and (3) "that the ranges of many southern and Appalachian species were abruptly terminated at varying distances south of the glacial boundary. These [species] have been able to advance greater or less distances toward or onto the glaciated area." Although the evidence for Dr. Braun's viewpoint is overwhelming and the arguments have subsided, the controversy continues. Deevey never replied.

CONTRIBUTIONS TO CONSERVATION

Dr. Braun's contributions to conservation are extremely important, but are difficult to describe because of the multiplicity of facets and directions this work took throughout her life. In 1917, the Ecological Society of America organized a committee on the preservation of natural conditions charged "with listing of all perserved and preservable areas in North America in which natural conditions persist" (Shelford, 1926). As the botany representative for Ohio, Dr. Braun described the criteria and goals of the project in the *Ohio Journal of Science* (Braun, 1922). She, along with Lynds Jones representing zoology (birds), prepared the treatment of the natural areas in Ohio for the resulting book, *Naturalist's Guide to the Americas* (Braun, 1926). This work was the first attempt at inventorying Ohio's natural areas. Dr. Braun, serving also as one of the associate editors for the entire book, prepared the chapter on *National Parks and National Monuments,* which included a list of these arranged in order of date of establishment, with selected publications on their features. In the preface to the *Naturalist's Guide,* Shelford (1926) wrote, "The associate editors did very much to improve the general character of the work, but credit should be especially given Dr. E. Lucy Braun who read the entire manuscript on states and provinces [p. 150-570], making important general criticisms."

In the spring of 1917, at the instance of Dr. Braun, several individuals, herself included, enrolled as members of the Wild Flower Preservation Society of America. In order to form local chapters, five members were required to act, and so on April 16, a letter of call was issued to interested persons in and around Cincinnati to meet on April 25 in the Botany Rooms of the University of Cincinnati. At this meeting the Cincinnati Chapter was organized with 72 charter members. Dr. Braun was named secretary and representative to the national chapter (Anonymous, 1924a). She continued as a representative to the national society and was one of its directors until at least 1937. The Cincinnati Chapter in 1924 began publishing *Wild Flower,* and a year later this magazine was selected as the official organ of the national society with

continued publication in Cincinnati (Anonymous, 1925). Dr. Harvey Wickes Felter was founder and editor until his death in October 1927. Annette Braun edited issue number one of volume five of *Wild Flower* in 1928, but beginning with issue number two of that year and continuing to the end of volume ten in 1933, E. Lucy served as editor. She was listed as a contributing editor until July 1941 (volume 18, number three) although her last article in the magazine was published in 1936. During this period, Dr. Braun contributed 33 signed articles, 68 unsigned articles, and 13 book notices.

As the titles of her many articles in *Wild Flower* (listed in the bibliography) reveal, conservation of wild plants, the importance of saving natural habitats of plants, and concern for the establishment of parks, nature preserves, and wilderness areas were stressed. Through *Wild Flower,* Dr. Braun proclaimed her ideas of conservation. One editorial stated her position clearly: "Destruction of beauty and vandalism are the result of ignorance, thoughtlessness, or defiance of the law and the rights of others. When perpetrated by those who because of their training and station in life should know better, despoiliation [sic] of nature should be doubly censured" (Braun, 1931). At the time of her resignation as editor of *Wild Flower,* Dr. Braun wrote (1933), "Press of other duties and the desire for more time for botanical research and [scientific] writing–not a decrease in interest in the cause of conservation–are responsible for the resignation of the present editor."

While serving for ten years (1923-1933) on the committee on State Parks and Conservation of the Ohio Academy of Science, Dr. Braun continued her efforts on conservation of native flora and the preservation of natural areas, as reviewed by Dexter (1962b). In 1927 she was appointed by the president of the Academy on a committee to serve as as an advisor "from the Academy to formulate regulations intended to preserve the biological status in the state forests." In 1932 she was appointed to represent Ohio on the Committee for the Preservation of Natural Conditions, sponsored by the Ecological Society of America, as that organization outlined plans for the preservation of natural communities by the creation of nature sanctuaries. At the national meeting of the Society in December 1935, Dr. Braun's "proposal of a plan for establishing National Primeval Monuments, principally as a means of preserving for all time some of the few remaining areas of primeval vegetation, was unanimously endorsed by the Society" (Vestal, 1936).

Too, Dr. Braun had her own projects–the saving of Buzzardroost Rock and Lynx Prairie, two dry prairies in the Mineral Springs region of Adams County, Ohio. Buzzardroost Rock, a prominent 152-acre unglaciated dolomite promontory in the southern part of the county, was acquired in 1960 by the Ohio Chapter of Nature Conservancy (Becker, n.d.). Original funds for purchase were contributed by three Cincinnati garden clubs in a drive spearheaded by Dr. Braun (Durrell, 1967). Through additional purchases, including 49 areas of mixed mesophytic forest, the area of the Buzzardroost Rock preserve has been increased to 386 acres (Annette Braun, 1972). The other prairie, named the "Lynx Prairie E. Lucy Braun Preserve" in 1965, is a tract of 53 acres south of the town of Lynx and was acquired by the Nature

Conservancy through the diligent efforts of members of the Ohio Chapter who solicited and raised the necessary funds for the purchase of the several holdings now included in the sanctuary ([Braun, 1967]). The Lynx Prairie was the Ohio Chapter's first land purchase project (Becker, n.d.). Both nature sanctuaries were deeded to the Cincinnati Museum of Natural History in the fall of 1967 (Durrell, 1967). At that time permanent markers were erected at both preserves with the following inscription:

BUZZARDROOST ROCK
LYNX PRAIRIE
Has Been Designated a
Registered
Natural Landmark
Under the provisions of the
Historic Sites Act of August 21, 1935
This Site Possesses Exceptional Value
In Illustrating the Natural
History of the United States

U.S. Department of the Interior
National Park Service
1967

The acquisition of a third area, the Wilderness (Charles A. Eulett Preserve), in Adams County was initiated through Dr. Braun's explorations. This area now comprises 362 acres, and additions are being made. An example of stream capture, a gorge with arbor vitae forest, mixed mesophytic forest, and prairie promontories and slopes are the features of this unique place (Annette Braun, 1972). Two other areas, Red Rock and a prairie at Lake Adams, have also been preserved. Today, a "Dr. Lucy Braun Memorial Fund" has been established by the Cincinnati Museum of Natural History to maintain and expand these five preserves (Anonymous, 1971d).

Dr. Braun's fight to save natural areas continued to the very end. As late as 23 October 1968, Professor Richard H. Durrell of the University of Cincinnati and then vice-president of the Ohio Chapter of the Nature Conservancy read Dr. Braun's prepared statement before a board of Ohio legislators charged with the study and recommendation of ways and means of conserving the remains of the state's heritage. Portions of Dr. Braun's statement (1968) were printed in the Newsletter of the Ohio Chapter of the Nature Conservancy, Autumn 1968, and are here quoted:

> Today the natural contest among the plants which produces natural plant successions is being overwhelmed by the larger and relentless battle with man. As a result of man's continuing destruction of his natural environment by the plow, lumbering, urban sprawl and ever enlarging highways, few natural habitats will shortly remain in Ohio. Although a few unviolated natural areas have already been preserved . . . by Nature Conservancy and the Ohio Historical Society, there are far too few.
>
> The battle to save our natural heritage in Ohio is being lost at an ever increasing rate. . . . A few states have taken a forward step to turn the tides of battle to preserve some of natural heritage for future generations. I firmly believe that Ohio must act now. . . .
>
> Let me emphasize that there should be three types of natural areas. The first and more common kind includes those areas which are chosen for scenic or recreational reasons. . . .

> A second and less common area should be the nature preserve. Here natural phenomena of great worth could be studied by small classes or groups under supervision of their teachers or leader. The fragile character and intrinsic worth of this type would be destroyed by heavy use.
>
> The third and rare type, areas which are important to the scientist and serious student, should serve as a sanctuary or refuge for plants and animals. These gems of nature and natural change cannot withstand even supervised class use.

In 1970, a Natural Areas Bill was passed by the Ohio State Legislature (Anonymous, 1970), and thus some of Dr. Braun's ideas expressed to the Legislature are on their way to becoming fulfilled.

Dr. Braun's efforts to prevent the destruction of the unique ecological features of the Red River Gorge in Kentucky by the Corps of Army Engineers should not be unmentioned. Forcibly expressed letters—supported by scientific data—to the Army Engineer headquarters have had some influence in slight lowering of the height of the dam as originally planned (Annette Braun, 1972).

MEMBERSHIP AND ACTIVITIES IN SCIENTIFIC AND CONSERVATION SOCIETIES

The scientific organizations of which Dr. Braun was a member reflect her interests in ecology, taxonomy, and conservation. Among these organizations were the American Association for the Advancement of Science, American Society of Plant Taxonomists, Botanical Society of America, and the British Ecological Society. In the Ecological Society of America she was chairman of the Resolutions Committee in 1934, vice-president in 1935, and president in 1950 (the only woman president of the Society). Much of her work in conservation was carried out through the Cincinnati Chapter and National Chapter of the Wild Flower Preservation Society (discussed above), the Cincinnati Museum of Natural History, Cincinnati garden clubs, the Ohio Chapter of the Nature Conservancy, and the Ohio Academy of Science.

In the latter organization, the Ohio Academy of Science, Dr. Braun was very active in several capacities throughout her professional career, having become a member in 1920 and being elected a fellow in 1921 (Alexander, 1931, 1941; Dexter, 1964, 1966; various Annual Reports of the Academy). Her affiliation was with Section B (Plant Sciences), where she served as vice-president for Botany in 1922-1923 and 1928-1929. She was on the Committee on State Parks and Conservation from 1923 to 1933, chairman of the Resolutions Committee in 1932, one of the trustees of the research fund from 1947 to 1950, chairman of the Ohio Flora Committee from 1951 to 1958, and president of the Academy in 1933-1934 (the only woman president of the Academy). Her presidential address was "A History of Ohio's Vegetation" (1934).

HONORS AND AWARDS

Shortly after her book on the *Deciduous Forests* (1950) was published, Dr. Braun began receiving a number of honors and awards for achievements in ecology and conservation. Chronologically they are

1952. Mary Soper Pope Medal, an award of merit in the field of botany, given by the Cranbrook Institute of Science, Bloomfield Hills, Michigan. The citation accompanying the award read in part:

> The Cranbrook Institute of Science, in awarding the Mary Soper Pope Medal to Professor Emeritus Emma Lucy Braun, honors one of America's major ecologists. Her studies of the natural vegetation of eastern North America over the past twenty years and more have led to the formulation of an original principle in vegetation dynamics. Her theory of the association-segregata [sic] is one of the most important and fertile theories to be proposed in recent years. Its implications reach far beyond the analysis of our native forests, concerning which it was originally elaborated.
>
> The unique background of E. Lucy Braun's researches combines an intimate knowledge of physiographic processes and a thorough familiarity with the eastern North American flora and its geological history. Her training in geomorphology was under the guidance of one of the masters of that science in this country, N. M. Fenneman. Her comprehension of taxonomy and floristics was elaborated in the company of the best phytogeographers of her generation, notably M. L. Fernald and H. A. Gleason. It would seem that she owes something to the latter in the development of her ecological thinking, as she also does to E. N. Transeau and to F. L. Clements. However, as her work now stands, it is entirely her own, and she has contributed as much as they to build up a new science and to give it new meanings. Although many ecologists have incorporated her ideas in their way of thinking, the vein is still a very rich one whose exploitation has only just begun. In recent years, Dr. Braun herself has shown how her interpretations can be substantiated by current discoveries in experimental taxonomy. Her willingness to modify her concepts, as evidence becomes available from other sources and neighboring disciplines, marks her as a true pioneer, unwilling to settle in quietude on the territory originally explored.
>
> The utter restraint of her writings and the severe discipline of her investigations may well serve as a model to scientists practicing in every field. Her terseness, however, does not hide her deep feeling for nature, which is poetic rather than scientific and which provides much of the motivation which neither exact observation nor intellectual speculation alone can provide. This too is an example.
>
> . . .
>
> Her recently published synthesis . . . , "Deciduous Forests of Eastern North America," . . . is no doubt one of the important books published in this field and belongs on the same shelf with Kerner's, "Das Pflanzenleben der Donauländer," Schröter's, "Das Pflanzenleben der Alpen," and Tansley's, "Vegetation of the British Isles."
>
> In awarding the Mary Soper Pope Medal to Dr. E. Lucy Braun, the Cranbrook Institute of Science honors a woman of character and integrity whose original accomplishments and distinguished career already have blazoned her to fellow-scientists and from whom much is still expected in her ever-active retirement. ([Dansereau, 1952]).

1953. Honorary Life Membership in the Cincinnati Wild Flower Preservation Society (Lampe, 1971).

1956. Certificate of Merit from the Botanical Society of America, one of 50 awarded at the celebration of the fiftieth anniversary of the founding of the Society. Dr. Braun was one of three women botanists given the certificate. The citation read:

> Emma Lucy Braun, for her contribution to our knowledge of the origin and structure of the Eastern American deciduous forest. Her critical evaluation

of the works of others, her capacity to observe correctly in the field and to interpret forcefully have given biogeographers a new point of departure (Meyer, 1956; 1958).

1961. Cited as one of 69 distinguished American botanists by the Botanical Society of America (Anonymous, 1961).

1963. Honorary Life Membership in the Ohio Academy of Science (Anonymous, 1963).

1964. Honorary Doctor of Science Degree from the University of Cincinnati (Anonymous, 1964).

1966. Eloise Payne Luquer Medal for special achievement in the field of botany at the annual meeting of the Garden Clubs of America in Baltimore (Anonymous, 1966).

1971. First woman to be listed in the Ohio Conservation Hall of Fame (Anonymous, 1971e; 1972).

RESEARCH SUPPORT AND ASSOCIATES

During her research career, Dr. Braun's work received substantial financial support. In her paper, "The Vegetation of the Mineral Springs Region of Adams County, Ohio" (1928, p. 515), she extended thanks to the Graduate School of the University of Cincinnati for "meeting all expenses incident to the field work." For several papers and for her definitive work on the *Deciduous Forests of Eastern North America* (1950, p. viii), she acknowledged grants-in-aid "from the American Association for the Advancement of Science (1932), the National Research Council (1934-35), and the American Association for the Advancement of Science through the Ohio Academy of Science (1938) [listed as 1939 by Alexander (1941) and Osborn (1944)]. A grant for typing of manuscript was received from the Research Fund of the Ohio Academy of Science (1947)." In 1943 and 1944 she was the recipient of a John Simon Guggenheim Fellowship which provided an opportunity of uninterrupted investigation for the *Deciduous Forests* book (p. viii; Anonymous, 1944).

In the preliminary phases of the research on the Ohio Flora Project, she received small contributions from the Ohio Academy of Science in 1951 and 1952 (Transeau, 1951; Barbour, 1952; Dexter, 1962a), and substantial grants from the National Science Foundation in 1956 and 1959 for the preparation, illustration, and publication of the *Woody Plants* (1961) and *The Monocotyledoneae* (1967). For her last major study, "The Vegetation of Fort Hill State Memorial" (1969), she was awarded substantial support from the National Science Foundation in 1965.

During her career, Dr. Braun had associated with her graduate students, assistants, and field companions. Her students were greatly influenced by her example and always held her in high regard. During the preparation of this paper, the names of the following graduate students (followed by the dates of their published thesis work as listed in the "References Cited") have come to my attention: Thomas J. Cobbe (1943), N. Mildred Irwin (1929), Dorothy Parker (1936), John C. Segelken (1929), Sylvia Geisler (1926), Isabel Thompson (1939), and Alice P. Withrow (1932). Mrs. Elizabeth Dalvé and

E. Lucy Braun standing between two white-cedar trees at Cedar Falls, Adams County, Ohio, ca. 1926. Left to right Mr. Conrad Roth, Dr. Braun, and Dorothy Parker. Photograph by Robert B. Gordon.

Mrs. Elizabeth King prepared the illustrations for *Woody Plants* and *The Monocotyledoneae*; 38 drawings from the latter book were recently reproduced with Dr. Braun's permission from the originals in *Michigan Flora* (Voss, 1972). Final drafting of the profiles, transects, and maps illustrated in the "Fort Hill" paper were completed by Mrs. Dalvé. Thomas R. VonBokern served as Dr. Braun's field assistant for the "Fort Hill" study.

Annette Braun accompanied her sister throughout all of the field studies, "beginning with horse-and-buggy trips in southwestern Ohio and later via Model T into remote areas of the Appalachians" (Anonymous, 1971c). In many of E. Lucy's publications, Annette's help is acknowledged in various ways–assistance in the construction and checking of maps, in final revision of the manuscript, in arranging the plates, and in reading of proof.

ENDURING ACHIEVEMENTS

Dr. Braun's contributions to science have been in plant ecology, floristics and taxonomy, phytogeography, and conservation. Examination of her publication record reveals an air of independence in her work, for in all of the scientific publications, Dr. Braun is the sole author of each work. Only in a few cases where she was involved in a committee effort within a Society, is a second author listed in her bibliography. Truly, her published work is her own observations, writing, conclusions, and interpretations. As quoted from a statement prepared by the memorial committee of the McMicken College of Arts and Sciences of the University of Cincinnati, "Let it be said that at all times Lucy Braun was a perfectionist striving for thoroughness and accuracy with meticulous attention to detail in her scientific work–a true scientist of whom the University of Cincinnati, The Nature Conservancy and the Cincinnati Museum of Natural History may well be proud" (Fulford, Dreyer, & Durrell, 1972).

Professor Richard H. Durrell (1972) tells of Dr. Braun's association with the Cincinnati Museum of Natural History. "She was one of the most faithful . . . and stimulating persons in the area of our four outdoor living museums. She not only found the areas that merited being preserved but with her enthusiasm and knowledge and taking time to go out with people to the preserves, was instrumental in enlisting their enthusiasm and quite often their funds. She was also constantly being consulted by the museum in connection with exhibits and other scientific materials."

Dansereau (1952, p. 330, in a review of *Deciduous Forests*) wrote, "She has certainly been one of the most original thinkers in the field of ecology in North America." I am sure *Deciduous Forests* will remain her most remembered and lasting scholarly achievement.

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1925. Through the long ages [migration and succession of vegetation into the glaciated area]. 2(3): 3-4.
1927. The lobelias. 4(4): 34-35.
1927. A September day. 4(4): 38-39.
1928. From winter to summer in a day in the Grand Canyon. 5(1): 3-4.
1928. Dog's tooth lilies (Erythroniums). 5(2):18-20.
1928. The milkwoods and their relatives. 5(3): 27-28.
1928. October in the dunes [of Lake Michigan]. 5(4): 42-43.
1928. The cone flowers. 5(4): 44-45.
1929. Christmas plants. 6(1): 5-8.
1929. Blue-eyed Mary or innocence (Collinsia). 6(2): 18-19.
1929. The dogwoods [*Cornus*]. 6(3): 26-28.
1929. An idle hour in the woods. 6(3): 32-33.
1929. Grass of parnassus [*Parnassia*]. 6(4): 40-41.
1930. Christmas plants: The conifers. 7(1): 4-7.
1930. The spring beauties [*Claytonia*] and their relatives. 7(2): 17-18.
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1936. The Save-Kentucky's-Primeval-Forest League. 13(1): 14.

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1928. Conservation work in the schools. 5(2): 13.
1928. Our national parks system. 5(2): 13-14.
1928. Nature and recreation. 5(2): 14.
1928. Wilderness areas. 5(3): 25.
1928. Great Smoky Mountains National Park. 5(3): 25-26.
1928. Forest fires. 5(3): 26-27.
1928. State parks and wild flower protection. 5(4): 37-38.
1928. Our Christmas greens. 5(4): 38-39.
1929. Popular appeals. 6(1): 1.
1929. A unique form of vandalism. 6(1): 1-2.
1929. Nature trails. 6(1): 2.
1929. Wild flower protection. 6(2): 13.
1929. Visual demonstrations an aid to conservation. 6(2): 13-14.
1929. What is a wilderness? 6(2): 14.
1929. A national flower. 6(2): 20-21.
1929. Wild flower cards. 6(2): 21.
1929. Schools for outdoor instruction in nature. 6(2): 21-22.
1929. An increasing peril. 6(3): 25-26.
1929. Your magazine. 6(3): 26.
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1929. For the enjoyment of others. 6(4): 37.
1929. National park standards. 6(4): 37-39.
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1930. Winter meditations. 7(1): 2.
1930. To lovers of Yellowstone. 7(1): 2.
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1930. "Everywhere the flowers are a calendar of the season." 7(1): 10-11.
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1930. The Quetico-Superior Country. 7(3): 26.
1930. Yellowstone again. 7(3): 26.
1930. The long lost Gordonia [*Gordonia alatamaha* or *Franklinia alatamaha*] 7(3): 32-33.
1930. Wild plants from seed. 7(4): 37.
1930. Aids. 7(4): 37.
1930. Federal aid for state parks. 7(4): 37.
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1932. The public domain. 9(3): 25.
1932. Fine forests. 9(3): 25-26.
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CHROMOSOME STUDIES OF SOME MOSSES OF THE DOUGLAS LAKE REGION. III

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In the course of field studies undertaken during the past summer, a number of species of mosses have been studied cytologically which are either new counts or verifications of counts made from other geographical regions throughout the world.

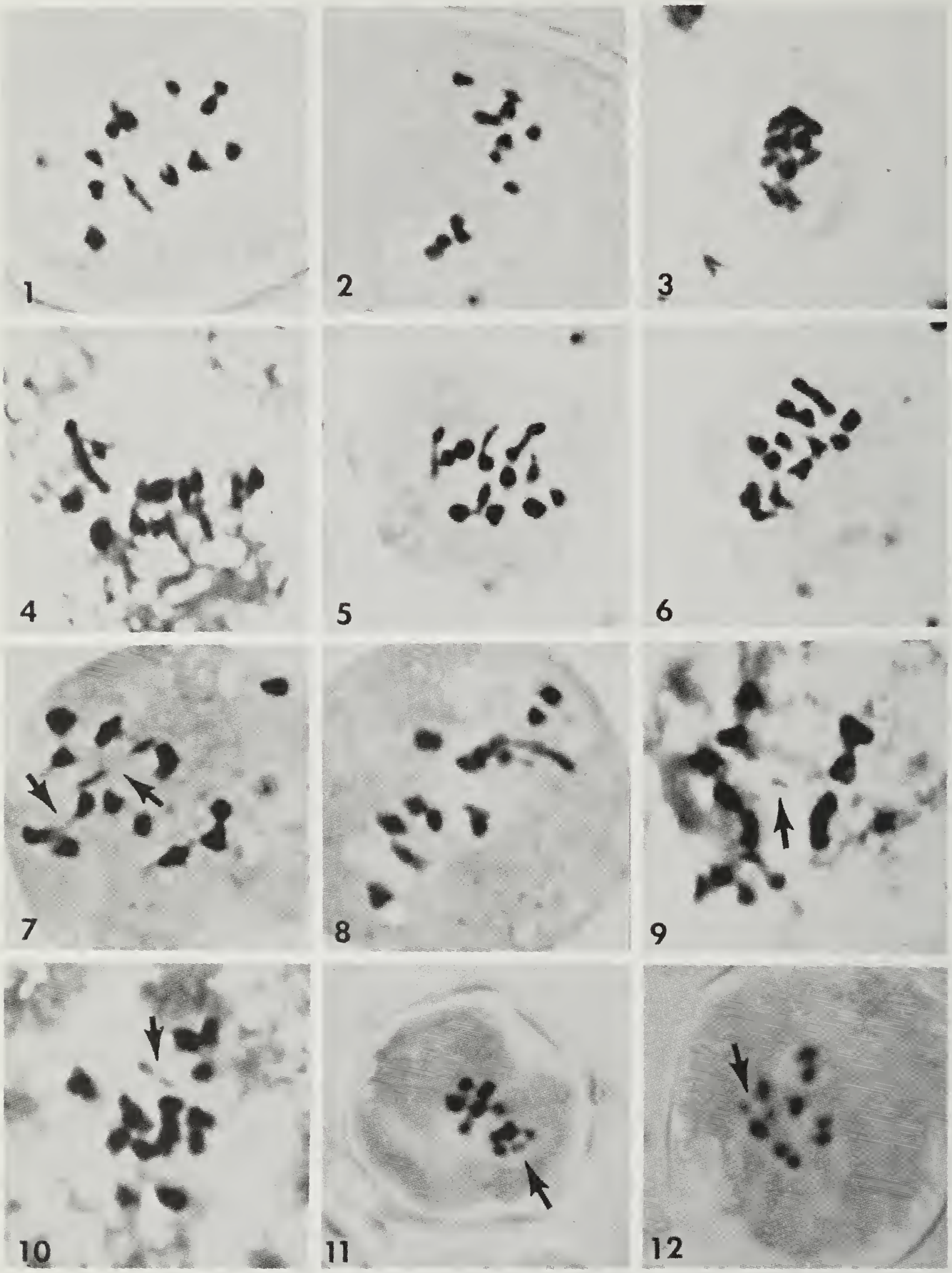
Collecting methods and meiotic techniques utilized in this study have been described previously (Snider, 1970, 1972).

Voucher specimens are deposited in the herbarium of Duke University and the author's personal herbarium.

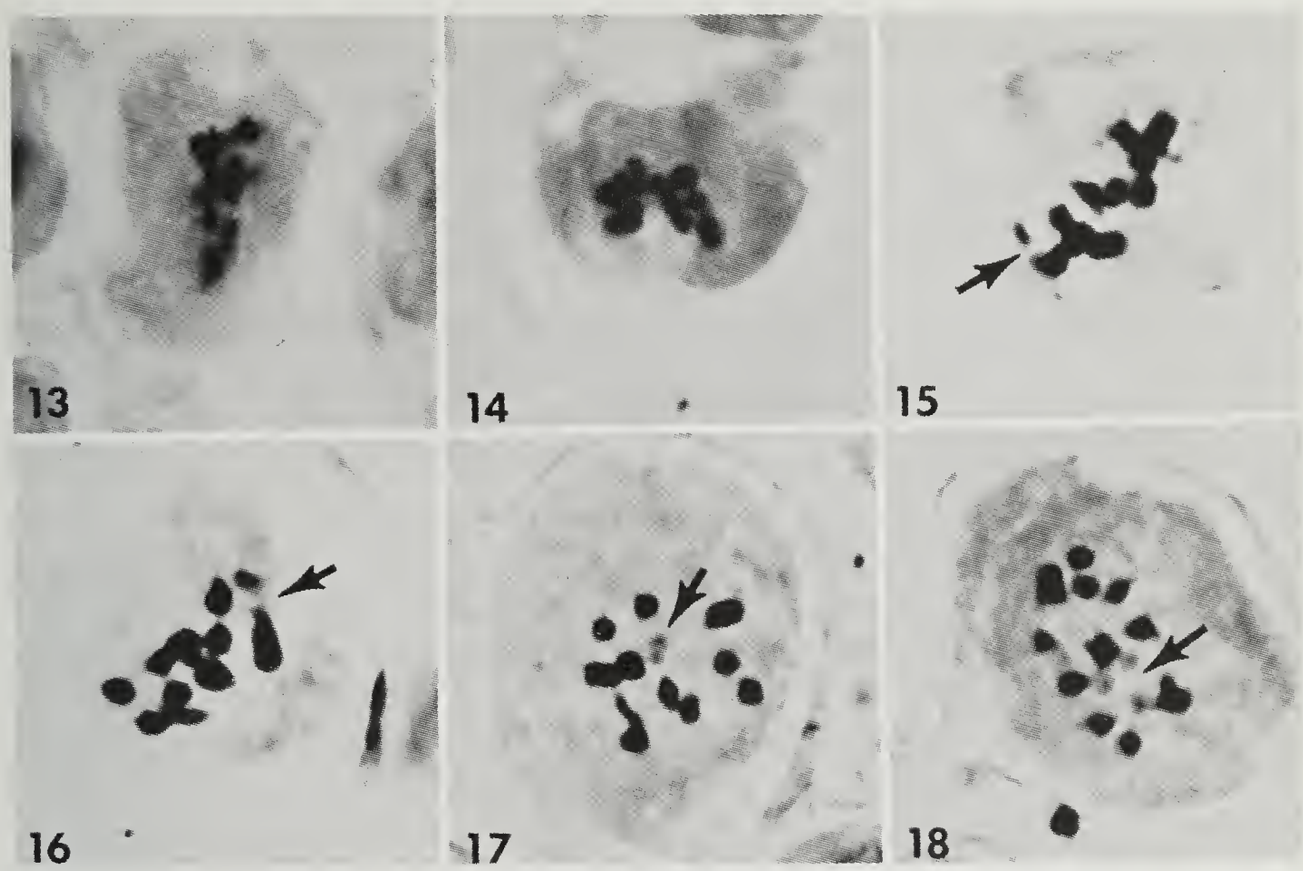
Fissidens osmundoides Hedw. n = 12 (figs. 1,2). On moist soil, bank of Carp Creek, Reese's Bog, Cheboygan Co., Michigan, 22 July 1972, *Snider 1443.* As discussed previously (Snider, 1970), Chopra (1961) had reported the number n = 16 from a population in the Great Smoky Mountain National Park, where he recognized four v-shaped bivalents. The present count agrees with a previous report (Snider, 1970) from the Douglas Lake area of the number n = 12. The bivalents in the present report, however, are of a much smaller size and one larger bivalent consistently undergoes early disjunction (fig. 1).

Seligeria calcarea (Hedw.) B.S.G. n = 12 + m (figs. 19, 20). On limestone, sinkholes south of Posen, Alpena Co., Michigan, 28 July 1972, *Snider 1444.* Lazarenko et al. (1971) summarized counts for this genus from the U.S.S.R., and reported the number n = 12 + 1 for *S. calcarea.* The number n = 12 + 1 was also reported for *S. doniana,* and the number n = 13 for *S. recurvata.* Smith and Newton (1968) reported the number n = 12 for *S. paucifolia* from the British Isles. Chromosomes from the Michigan population were comprised of three size groups: three large bivalents with two to three chiasmata, six medium, and four smallish bivalents, the smallest undergoing early disjunction during metaphase I and, on occasion, each half-bivalent dividing into its respective sister chromatids immediately after the large bivalents disjoin during anaphase I. Although the tiny bivalent disjoins precociously, it stains brilliantly, unlike other m-chromosomes.

Dicranella heteromalla (Hedw.) Schimp. n = 11 (figs. 3, 21, 22). On shaded roadside bank, Middle Village Rd., Emmet Co., Michigan, 28 July 1972, *Snider 1445.* This report adds yet another count for this species. Yano (1954) first reported the number n = 13 from a Japanese population. Khanna (1960) reported the number n = 13 from the Himalayas and (1964) the number n = 13 + 2-3 fragments from a population from the Adirondack Mountains in New



Figures 1-12. ca. ×3800 Figs. 1-2. *Fissidens osmundoides,* n = 12. Fig. 3. *Dicranella heteromalla,* n = 11. Fig. 4. *Gymnostomum recurvirostrum,* n = 13. Figs. 5-6. *Tortella tortuosa,* n = 13. Figs. 7-8. *Bryoerythrophyllum recurvirostrum,* n = 13. Figs. 9-10. *Meesia uliginosa,* n = 13 + m. Figs. 11-12. *Drepanocladus uncinatus,* n = 9 + m. Arrows indicate disjoining bivalents and m-bivalents. Refer to text for descriptions.



Figures 13-18. ca. ×3800. Figs. 13-14. *Plagiothecium denticulatum,* n = 11. Figs. 15-16. *Hypnum pallescens,* n = 10 + m. Figs. 17-18. *Herzogiella turfacea,* n = 11 + m. Arrows denote m-bivalents. Refer to text for descriptions.

York. Smith and Newton (1966) also reported the number n = 13 from the British Isles, and Lazarenko and Visotskaya (1965) reported the same number from the U.S.S.R. Ireland (1967) reported counts of the number n = 13 from the Pacific Northwest. Inoue (1965) however, reported the number n = 14 in mitotic studies of a population from Japan. Published counts for the genus vary, the numbers n = 10,12,13,14,15, and 16 having been reported. Thus, it is not too surprising that the number n = 11 has now been observed. Anderson and Bryan (1958) suggest that the basic number in the genus may be 5, that the n = 15 species are gametophytically triploid, and the 14 and 13 chromosome races are well-established aneuploids in which the chromosome morphology has been altered. Apparently the present count represents another aneuploid in the genus. One bivalent was observed to disjoin early in several preparations; otherwise meiosis was normal and the bivalents were of a uniform size. Karyotype studies of mitotic preparations are needed to explain the aneuploidy that exists in this troublesome genus. Meiosis occurred when the capsule was yellow-green in color, with no color differentiation in the annulus or operculum.

Gymnostomum recurvirostrum Hedw. n = 13 (figs. 4,23,24). On sandstone, Pictured Rocks, Alger Co., Michigan, 3 August 1972, *Snider 1446.* The number n = 13 is the first report for this species from North America. It also agrees with mitotic counts made by Ramsay (1968) from a British population.

She observed one large chromosome with a median kinetochore and secondary constriction, two long chromosomes, one with a metacentric kinetochore and the other with a subterminal kinetochore, six intermediate, three small, and one tiny chromosomes. In the Michigan population studied, one large bivalent with a subterminal kinetochore, two intermediate bivalents, and ten smaller, rather uniform bivalents were observed. Gangulee and Chatterjee (1962) counted the number n = 12 + m from a population from eastern India. Except for the m-bivalent and a large chromosome, they reported all bivalents were approximately equal in size. No m-bivalent was observed in the Michigan counts. Meiosis occurred when the capsule was a yellow-green in color, while the base of the capsule and the annulus region exhibited a definite red-brown color.

Tortella tortuosa (Hedw.) Limpr. n = 13 (figs. 5,6,25,26). On sandy soil near Hessel, Mackinac Co., Michigan, 19 July 1972, *Snider 1447.* The number n = 13 is in agreement with reports by Anderson and Crum (1958) from Canada, and reports summarized by Lazarenko et al. (1971) from the U.S.S.R. In the Michigan population studied, the SMC and the chromosomes were quite small, although not approaching the size observed by Anderson and Crum. The material was very easy to prepare and the chromosomes stained deeply and rapidly with aceto-orcein. One bivalent was quite large, had subterminal kinetochores, and was conspicuous in all preparations studied. The twelve remaining bivalents were of a uniform size. Meiosis occurred when the capsule was yellow-green and the operculum a shiny reddish-brown color.

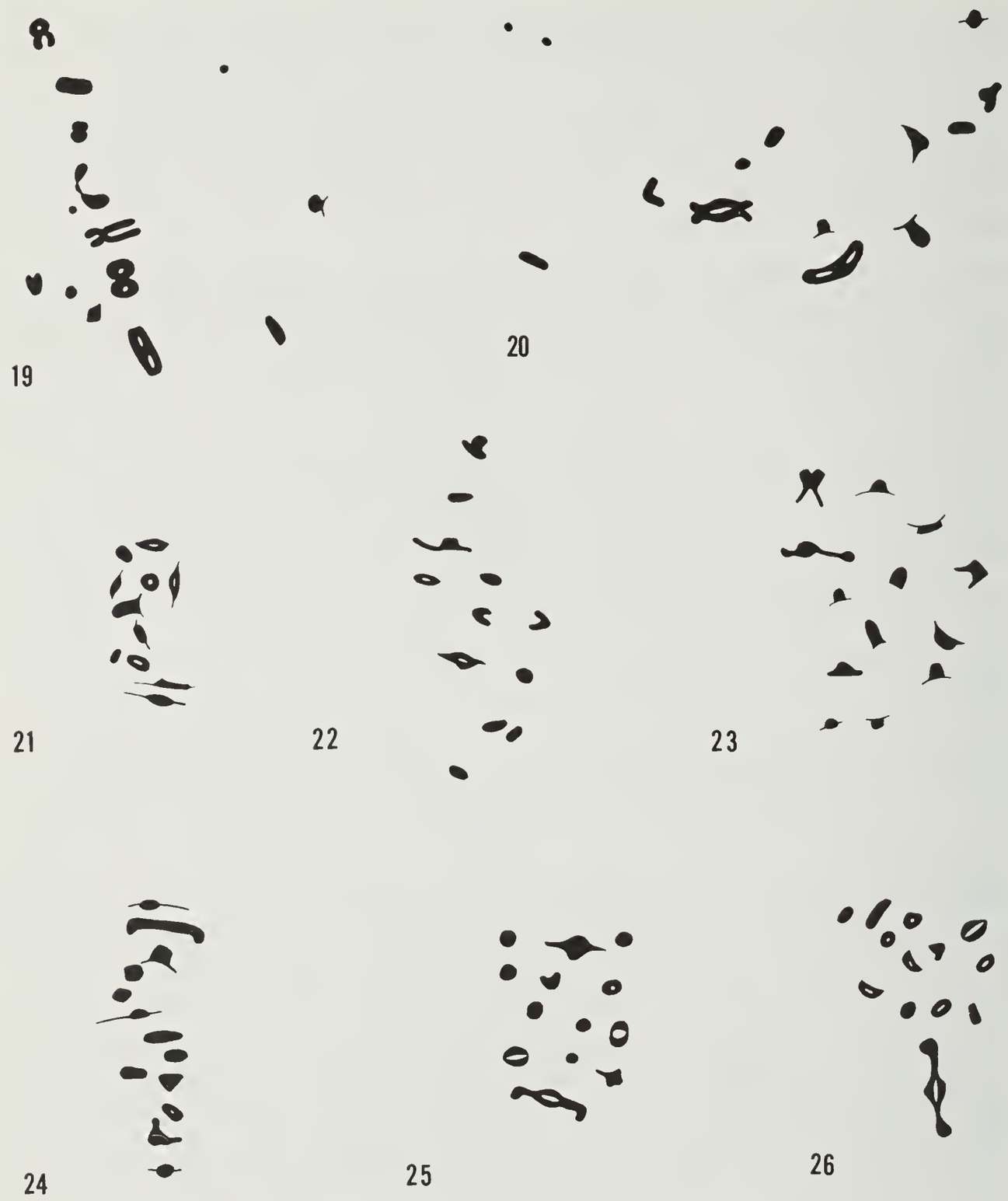
Bryoerythrophyllum recurvirostrum (Hedw.) Chen n = 13 (figs. 7,8,27,28). On soil, Bush Bay, Mackinac Co., Michigan, 19 July 1972, *Snider 1448;* on soil, Mill Creek, Cheboygan Co., Michigan, 31 July 1972, *Snider 1449.* The number n = 13 agrees with all previous reports for this species (Steere, 1954; Anderson & Crum, 1958; Khanna, 1959, 1960; Visotskaya, 1967), although Lazarenko et al. (1971) do mention one report of the number n = 13 + 1 from the U.S.S.R. In both Michigan populations studied, 13 clear, deeply staining bivalents were observed, with one characteristic, large bivalent with subterminal kinetochores disjoining early (figs. 7,28). Meiosis occurred while the capsule, annulus, and operculum were green in color.

Meesia uliginosa Hedw. n = 13 + m (figs. 9,10,29,30). On old sand dunes, Evergreen Beach, Presque Isle Co., Michigan, 30 June 1972, *Snider 1450.* Anderson and Crum (1958) have reported the number n = 13 for this species from the Canadian Rocky Mountains. Smith and Newton (1968) reported the number n = 14, which included a tiny m-bivalent, in a population from the British Isles. Ramsay (1968) studying material from the same locality in the British Isles, reported the number n = 14 + m. In the Michigan material studied, numerous oil bodies were observed in the unsquashed SMC; however, upon squashing the cytoplasm became quite clear and the chromosomes stained intensely. The bivalents were large and quite uniform in size except for the faintly staining, tiny m-bivalent. The m-bivalent typically disjoined

during metaphase I, and during anaphase I separated into its respective sister chromatids (fig. 30). Six bivalents appeared to have median kinetochores, two had subterminal kinetochores, and five had terminal kinetochores. During anaphase I two bivalents were observed to lag consistently in their poleward migration (fig. 30). Meiosis occurred when a definite light brown color was exhibited in the annulus and the tip of the operculum was brownish, shading into a light green at its base.

Drepanocladus uncinatus (Hedw.) Warnst. n = 9 + m (figs. 11,12,31,32). On rotting log, Reese's Bog, Cheboygan Co., Michigan, 14 July 1972, *Snider 1451.* Numerous preparations were made from this collection and in every case the number n = 9 + m was recorded. Four large bivalents, two with terminal or subterminal kinetochores and two with median kinetochores, were observed. The remaining six bivalents were much smaller and of a uniform size. One of the small bivalents stained faintly, disjoined precociously during metaphase I, the half-bivalents separating into their respective sister chromatids during early anaphase I. Figure 11 shows one half-bivalent (arrow) separating into sister chromatids, while the other half-bivalent has not separated at this point. Steere (1954) reported the number n = 12 from an Alaskan population, as also do Chopra and Kumar (1967) from India, Ireland (1967) from Washington, and Khanna (1967) from Colorado. Anderson and Crum (1958) reported the numbers n = 12,20 in four populations from the Canadian Rocky Mountains. Lazarenko et al. (1971) reported the number n = 10,20 in their summary of counts published from the U.S.S.R. Smith and Newton (1967) also reported the number n = 10, with two precociously disjoining bivalents and one lagging bivalent observed during meiosis. Ramsay (1968) observed the number n = 10 in her mitotic studies of a population from the British Isles, and reported two large, two intermediate, and six small bivalents in her count. Vaarama (1950) reported the number n = 12 in material from Finland, and recognized a heterochromatic "special" bivalent which behaved normally through metaphase-anaphase I. The occurrence of ten bivalents in the Michigan population is not surprising in view of the other reports. The presence of what is apparently an m-bivalent is difficult to interpret, however. Although slightly larger in size than other m-chromosomes, it exhibits all the characters associated with m-bivalents, i.e. faintly staining, precocious disjunction, and each half-bivalent separating into its respective sister chromatids.

Plagiothecium denticulatum (Hedw.) B.S.G. n = 11 (figs. 13,14,33,34,35). On soil, Reese's Bog, Cheboygan Co., Michigan, 1 July 1972, *Snider 1452.* The numbers n = 10,11,20,25 have been reported previously for this highly polyploid species. The present report is in accord with reports of the number n = 11 (Vaarama, 1956; Khanna, 1967; Ireland, 1969; Inoue & Uchino, 1969; Lazarenko et al., 1971), but differs from reports of the number n = 10 (Vaarama, 1950; Yano, 1957a,b; Ireland, 1969), and the number n = 20 (Anderson & Bryan, 1958; Al-Aish & Anderson, 1960; Ireland, 1969). Anderson and Crum (1958) also reported the number n = 25 from plants



Figures 19-26. ca. ×3800. Figs. 19-20. *Seligeria calcarea,* n = 12 + m. Figs. 21-22. *Dicranella heteromalla,* n = 11. Figs. 23-24. *Gymnostomum recurvirostrum,* n = 13. Figs. 25-26. *Tortella tortuosa,* n = 13. Drawings made from photographic negatives and camera lucida illustrations.

Figures 27-35. ca. ×3800. Figs. 27-28. *Bryoerythrophyllum recurvirostrum,* n = 13. Figs. 29-30. *Meesia uliginosa,* n = 13 + m. Figs. 31-32. *Drepanocladus uncinatus,* n = 9 + m. Figs. 33-35. *Plagiothecium denticulatum,* n = 11. Drawings made from photographic negatives and camera lucida illustrations.

Figures 36-43. ca. ×3800. Figs. 26-37. *Plagiothecium laetum,* n = 10 + m. Figs. 38-39. *Hypnum pallescens,* n = 10 + m. Figs. 40-43. *Herzogiella turfacea,* n = 11 + m. Drawings made from photographic negatives and camera lucida illustrations.

from the Canadian Rocky Mountains. Ireland (1969) has discovered that the morphology of the polyploid races differs somewhat from the diploids in many respects, although he believes that these character differences are not important enough to warrant toxonomic distinction. Detailed chromosome studies appear to be needed in view of the high degree of polyploidy exhibited in this polymorphic species. The bivalents in the Michigan population were small, rather uniform in size, and one to two bivalents usually disjoined during metaphase I (figs. 33,35).

Plagiothecium laetum B.S.G. n = 10 + m (figs. 36,37). On soil, Reese's Bog, Cheboygan Co., Michigan, 18 July 1972, *Snider 1453.* Anderson and Al-Aish (1963) reported the number n = 10 + m from a New York population. Ireland (1969) reported the numbers n = 10,11 from numerous Washington populations. Unlike the present report, or that of Anderson and Al-Aish, Ireland observed the m-bivalent only in the populations with ten bivalents. Lazarenko et al. (1971), in a summary of counts from the U.S.S.R., report the number n = 11. In the Michigan material three large, three intermediate, and five small bivalents, including the m-bivalent, were observed. Ten bivalents stained brilliantly, and meiosis was normal except for the precociously disjoining m-bivalent.

Hypnum pallescens (Hedw.) P. Beauv. n = 10 + m (figs. 15,16,38,39). On rotting log, Reese's Bog, Cheboygan Co., Michigan, 15 July 1972, *Snider 1454;* on rotting log, near Hessel, Mackinac Co., Michigan, 9 July 1972, *Snider 1455;* on sandy soil, Lark Lake, Emmet Co., Michigan, 15 July 1972, *Snider 1456.* This apparently is the first published report for this species in North America. Lazarenko et al. (1971) summarized two reports from the U.S.S.R., both having the number n = 11. In the Michigan populations studied, the chromosomes stained deeply and could be studied immediately after preparation. Three large bivalents, seven small bivalents, and the faintly staining, precociously disjoining m-bivalent were observed in all preparations. Meiosis occurred when the capsule, annulus and operculum were all a uniform bright green in color.

Herzogiella turfacea (Lindb.) Iwats. n = 11 + m (figs. 17,18,40,41,42,43). On rotting log, Reese's Bog, Cheboygan Co., Michigan, 15 July 1972, *Snider 1457.* Vaarama (1950) reported the number n = 11 for a Finnish population (as *Isopterygium turfaceum*) and Bird (1962) reported the number n = 11 for a Canadian population (as *Plagiothecium turfaceum*). Bivalents in the Michigan population studied stained deeply and separated nicely when squashed. The complement consisted of two large bivalents, six intermediate and four small bivalents, one of which is the m-bivalent. The m-bivalent is very faint (figs. 17,18), disjoins during metaphase I into two half-bivalents, and during anaphase I the half-bivalents separate into their respective sister chromatids (figs. 18,42,43). Meiosis occurred when a brownish tinge was observed in the tip of the operculum.

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I wish to express my appreciation to Dr. Lewis E. Anderson of Duke University for suggested changes in the manuscript, and to Dr. Howard A. Crum of the University of Michigan for his aid in collecting and identifying the specimens studied. I am also grateful for the facilities provided at the University of Michigan Biological Station. This research was partially supported by National Science Foundation Grant GB-27365, Duke University.

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LEUCOBRYUM ALBIDUM NEW TO MICHIGAN

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Leucobryum glaucum (Hedw.) Fries, the White Moss or Pincushion Moss, is common on wood humus in wet habitats throughout Michigan, often forming extensive mounds several feet across marking the position of wood humus resulting from extreme decomposition of a stump or a log. Farther south a related species, *L. albidum* (Brid.) Lindb., is more often encountered, usually on humic soil in relatively dry habitats, such as the banks of wooded ravines. It ranges widely from Rhode Island to Florida and west to Wisconsin, Oklahoma, and Texas, and it was therefore no great surprise to me to find it in southernmost Michigan, in Washtenaw County (on soil, open oak-hickory stand, St. Louis School for Exceptional Boys, Old U.S. 12 near Hayes Road, R3E, T2S, sec. 30, September 30, 1972). The species is easy to recognize as distinct from *L. glaucum* by its growth in small, compact tufts only about 1 cm high. The leaves are about 2-4 mm long, with the point about the same length as the base. The costa (which fills most of the leaf) consists of 2 (or rarely, here and there, 3) hyaline cells both above and below the green cells at the thickest part of the leaf base.

STUDIES ON MICHIGAN CHRYSOPHYCEAE. II

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During the past two years we have been making a taxonomic study of the Chrysophycean flora of Michigan with particular emphasis on the scaled species. We have found that for these species, as in other groups of algae, distributions are not well known in North America, particularly in the continental United States. We hope that study of Michigan specimens will result in a better understanding of the distribution of the Chrysophyceae.

METHODS

Collecting methods and locations utilized in this study have been described previously (Wujek & Hamilton, 1972). Two additional collecting sites were included in the August-October, 1971, collecting period. These were the Vestaburg Bog (Montcalm Co., Richland Twp., Sec. 34) and the Kalamazoo River (Calhoun Co., Bedford Twp., Sec. 30).

An asterisk before the name indicates a taxon here first reported for the state.

MALLOMONAS

**Mallomonas acaroides* var. *crassisquama* Asmund (Fig. 1)

Electron micrographs of scales of this species were described by Asmund (1959) from plankton collected in Denmark. In her report, Asmund suggests that this probably is a wide spread species in the northern latitudes. This is borne out by recent observations in Japan (Takahashi, 1961), Iceland (Bradley, 1964), Alaska (Asmund & Hilliard, 1961), and Finland (Asmund, 1959). Our specimens were found in Lake Isabella.

**Mallomonas acaroides* var. *striatula* Asmund (Fig. 2)

This variety is characterized by the dimorphism of the bristles, and was described from localities in Denmark (Asmund, 1959). The occurrence of this taxon in Lake Isabella is the basis for this first report for North America.

**Mallomonas striata* Asmund (Fig. 3)

This species, as described from material collected in Denmark, is a common cold-water one. In addition to our collection from Calhoun County, it has been reported previously from Denmark and England (Asmund, 1959), Japan (Takahashi, 1960), and Iceland (Bradley, 1964).

**Mallomonas oviformis* Nygaard (Fig. 4)

Mallomonas oviformis was described by Nygaard (1949) whose studies were made with the optical microscope. Asmund (1959) added electron micrographs. It has been previously reported from eutrophic ponds and

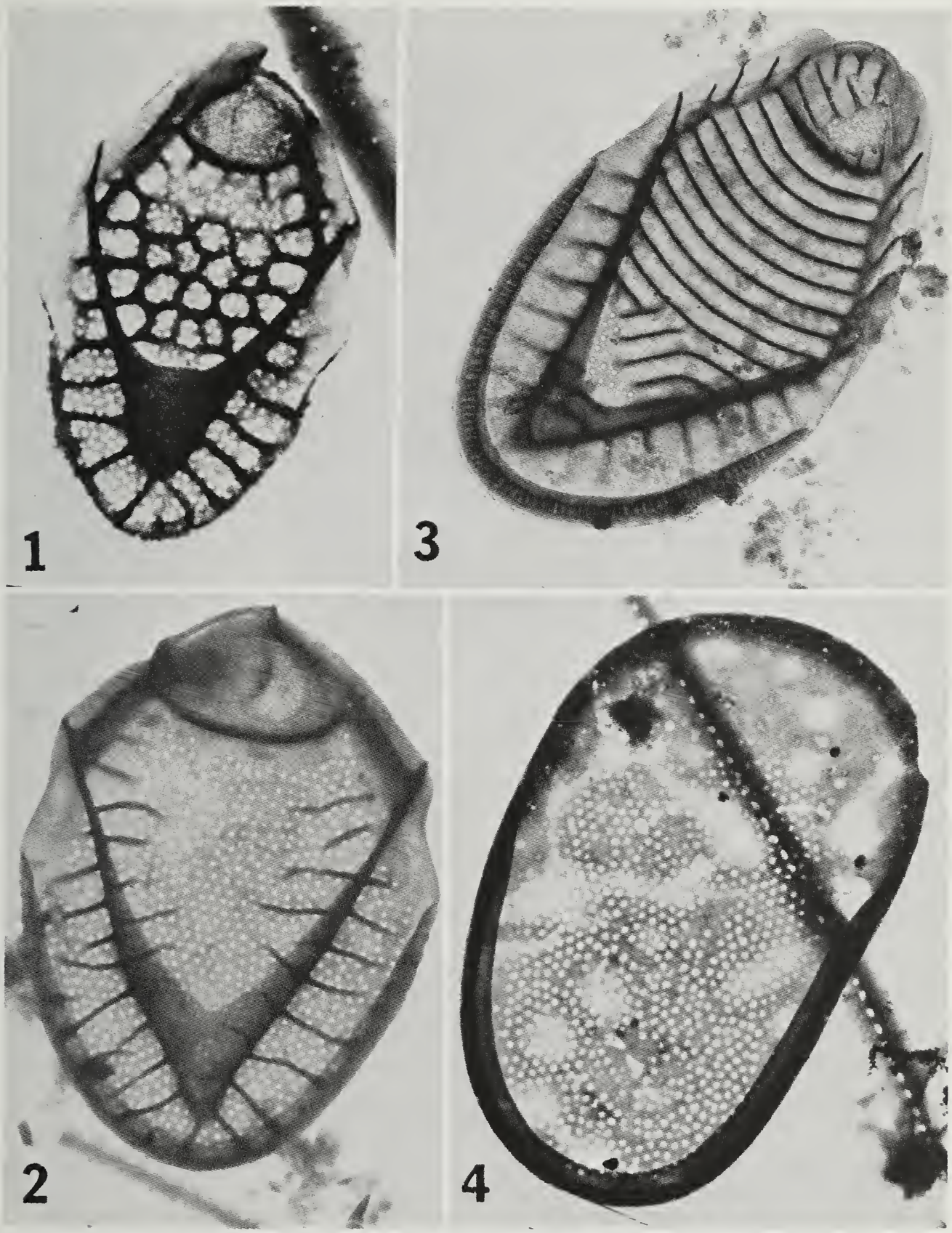

Fig. 1. *Mallomonas acaroides* var. *crassisquama,* ×16,000. Fig. 2. *M. acaroides* var. *striatula,* ×16,000. Fig. 3. *M. striata,* ×22,000. Fig. 4. *M. oviformis,* ×11,000.

Fig. 5. *Mallomonas tonsurata,* ×4,000. Fig. 6. *Synura echinulata,* ×11,000. Fig. 7. *Paraphysomonas vestita,* ×5,600.

ditches in England (Harris & Bradley, 1960) and in Denmark (Nygaard, 1949; Asmund, 1959). We have found it fairly common in Koehler's Pond and Lake Isabella, two recently created man-made impoundments.

**Mallomonas tonsurata* Teiling emend. Krieger (Fig. 5)

Teiling (1912) did not observe the structure and arrangement of the scales nor the structure of the bristles in his original description of *M. tonsurata.* A more detailed description was given by Krieger (1930). It has been found in several eutrophic ponds and lakes in Denmark (Asmund, 1959), Japan (Takahashi, 1959) and in the United States (Meyer & Brook, 1969; Whitford & Schumacher, 1969). Our specimens were collected from Lake Isabella.

SYNURA

**Synura echinulata* Korsh. (Fig. 6)

Synura echinulata has been thoroughly described by many investigators and many electron micrographs have been published. In addition to his native Japan, Takahashi (1967) reviews the numerous European localities for it. In addition to our observations of scales from Koehler's Pond and the Vestaburg Bog, it has also been previously reported for the United States from Minnesota (Meyer & Brook, 1969) and Alaska (Hilliard, 1968).

PARAPHYSOMONAS

**Paraphysomonas vestita* (Stokes) de Saedeleer (Fig. 7)

Paraphysomonas is a heterokont, colorless flagellate of the *Ochromonas* type and thus a member of the Chrysophyceae. Both stalked and free-swimming states are known. The cell surface is covered with numerous detachable scales; numbers of the order 100+ per cell have been reported (Manton & Leedale, 1961). Investigations by Korshikov (1929) of the chemical nature of the scales led him to the conclusion that they were composed of silica.

Paraphysomonas has been observed once previously in the United States from Kansas (Thompson & Halicki, 1965) as well as from Japan (Takahashi, 1959, 1960), Germany (Houwink, 1952), and Great Britain (Manton & Leedale, 1961). We have observed scales of it from Barney's Lake and St. James Harbor.

SUMMARY

Seven taxa of Chrysophyceae are new records for the state of Michigan. All but three species, *Mallomonas tonsurata, Synura echinulata,* and *Paraphysomonas vestita,* are new records for the continental United States.

ACKNOWLEDGMENTS

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CHROMOSOME NUMBERS IN *CLINTONIA BOREALIS* (LILIACEAE)

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The genus *Clintonia* (Liliaceae) consists of six species of herbaceous, perennial plants. In North America *C. alleghaniensis* Harned, *C. borealis* (Ait.) Raf., and *C. umbellulata* (Michx.) Morong occur in the east (Fig. 1) whereas *C. uniflora* (Schult.) Kunth and *C. andrewsiana* Torr. are native to the western portion of the continent. One species, *C. udensis* Trautv. & Mey., occurs in eastern Asia.

All of the species studied have a chromosome number of 2n = 28 (Sato, 1942; Hara & Kurosawa, 1963; Kurosawa, 1966, 1971; and Cave, 1970) with the exception of *C. borealis*. Plants of *C. borealis* have been recorded with chromosome counts of 2n = 28 (Smith, 1911; Kawano, 1965) or 2n = 32 (Walker, 1944; Löve & Löve, 1966; Dr. James Pringle, personal communication). The chromosome number of the rare *C. alleghaniensis* described by Harned (1931) (and known only from four stations in West Virginia) is not known.[1] This paper discusses the basis for the different chromosome numbers in *C. borealis*.

MATERIALS AND METHODS

Root tips and buds of *C. borealis* were collected from various localities in eastern North America (Table 1). The excised root tips were pretreated in a

[1]The authors searched for the populations in the spring of 1971 but failed to locate the plants.

0.002 M 8-hydroxyquinoline solution for 6-8 hours, fixed in ethanol-acetic acid (3:1) for 12 hours, and stored in 70% ethanol. Prior to staining, the root tips were hydrolyzed in 1 N HCl at 60C for one minute. The tissue was then squashed in aceto-carmine.

The flower buds were fixed in ethanol-acetic acid (3:1) for 12 hours and then stored in 70% ethanol. The pollen mother cells were squashed in aceto-carmine.

CYTOLOGY

The populations of *C. borealis* studied are listed in Table 1. The three populations with a count of 2n = 32 were found at the higher elevations of eastern North America (Löve and Löve, 1966; Pringle, personal communication).

A karyotype for *C. borealis* (2n = 28) was constructed (Fig. 2) from root tip chromosomes. The longest pair of chromosomes averaged 12.5 μ with the smallest 4 μ in length. The two pairs of long chromosomes possessed median centromeres. The rest of the karyotype had sub-metacentric centromeres. The karyotype for *C. borealis* 2n = 32 is identical to 2n = 28 except that two additional pairs of chromosomes the size of the pair number 14 are present.

Meiosis in the pollen mother cells of plants with a somatic chromosome number of 28 was analyzed. The most frequent metaphase I configuration was 14 pairs of chromosomes (Fig. 3); however, many cells displayed 12 pairs and 4 univalents or 13 pairs and 2 univalents. At both diplotene and pachytene the univalents were tightly condensed and stained darkly. Frequently at anaphase I, the univalents preceded the bivalents to the poles (Fig. 3). When four univalents occurred, centromeric activity was usually upset with precocious reductional segregation taking place. Anaphase I and II bridges, with and without fragments, were also observed in the cells (Fig. 3).

DISCUSSION

The rhizomes of *C. borealis* have a chromosome number of 2n = 28 or 2n = 32 with many chromosomal abnormalities in the meiotic cells. Potential gametes with chromosome numbers varying from n = 12 to n = 16 are possible because of the presence of univalents. Elimination of accessory chromosomes in roots during development has been reported for *Poa alpina* (Müntzing, 1946, 1948), *Haplopappus gracilis* (Östergren & Fröst, 1962), and other plants, although the same number is retained in the germ line. Whether such an elimination mechanism occurs in *C. borealis* remains uncertain. The chromosome base number for the genus *Clintonia* can quite confidently be placed at x = 14 and not x = 16 or 18 (Stebbins, 1971) since all species with the exception of *C. borealis* have a chromosome number of 2n = 28.

Additional chromosome counts of 2n = 32 were supplied by Dr. James Pringle from material collected in the White Mountains, New Hampshire. Löve and Löve (1966) also reported 2n = 32 from Mount Washington, New Hampshire. The existence of a 2n = 32 chromosomal race confined to the

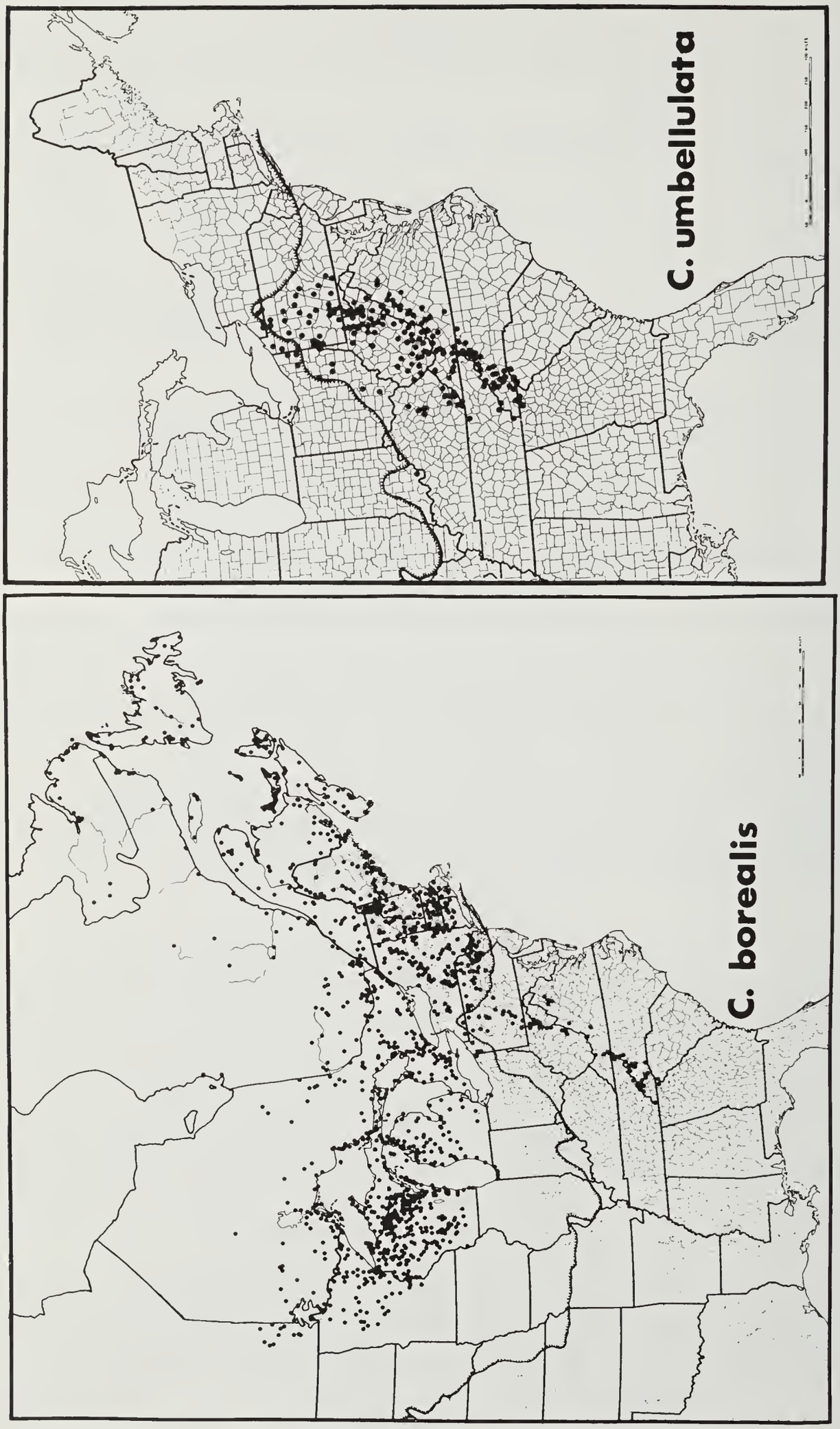

Fig. 1. Distribution of eastern species of *Clintonia*.

TABLE 1. Populations of *Clintonia borealis* Utilized in Study. The chromosomes of ten plants were examined in each population.

2N	N	Localities and Collectors
–	14	MICH.: Houghton Co., Laurium, Lake Linden. *Utech 306.* 14 May 1971.
–	14	MICH.: Menominee Co., along U.S. 2, 4 mi. W of Spalding. *Utech 302.* 14 May 1971.
–	14	MINN.: St. Louis Co., Rollins, King Lake, Cloquet Valley State Forest. *Utech 304.* 16 May 1971.
28	–	W. VA.: Pendleton Co., Monongahela National Forest, Spruce Knob, elev. 3940 ft. *Utech 208.* 28 Aug. 1970.
32	–	W. VA.: Pendleton Co., Monongahela National Forest, Spruce Knob, elev. 4850 ft. *Utech 209.* 28 Aug. 1970.
28	–	W. VA.: Randolph Co., Dolly Sods, 7 mi. NE of Harman, Monongahela National Forest. elev. 3660 ft. *Utech 205.* 28 Aug. 1970.
28	–	W. VA.: Tucker Co., Backbone Mt., Olson's Tower. elev. 3580 ft. *Utech 201.* 26 Aug. 1970.
–	14	WIS.: Door Co., Cave Point County Park, T. 20 N, R. 25 E, S. 16. *Utech 111.* 17 May 1970.
–	14	WIS.: Florence Co., Emily Lake, T. 39 N, R. 18 E. *Utech 114.* 17 May 1970.
28	14	WIS.: Forest Co., Alvin, T. 40N, R. 13E, S. 1. *Utech 115.* 17 May 1970.
–	14	WIS.: Forest Co., Wabeno, Lake Richardson, T. 34N, R. 14E, S. 11. *Thien 102.* 16 May 1970.
28	14	WIS.: Iron Co., Minnow Lake, T. 42N, R. 2E, S. 29. *Thien 101.* 16 May 1970.
28 12 II + 4 I 13 II + 2 I	14	WIS.: Juneau Co., Rocky Arbor roadside park. *Utech & Thien 108.* 14 May 1970.
–	14	WIS.: Langlade Co., NE of Neva on Co. A. T. 32N, R. 11E, S. 14. *Thien 103.* 16 May 1970.
–	14	WIS.: Langlade Co., 8 mi. E of junction of Cos. C and V. T. 32N, R. 10E, S. 30. *Thien 104.* 16 May 1970.
–	14	WIS.: Lincoln Co., Turtle Lake, 1.5 mi. W of Irma. T. 33N, R. 6E, S. 12. *Thien 100.* 16 May 1970.
–	14	WIS.: Manitowoc Co., Point Beach State Park, T. 20N, R. 25E, S. 16. *Utech 110.* 15 May 1970.
–	14	WIS.: Marinette Co., 1.5 mi. NE of Pembine, T. 37N, R. 20E, S. 26. *Utech 113.* 17 May 1970.
28	14	WIS.: Menominee Co., 2 mi. SE of Neopit. T. 29N, R. 14E, S. 27. *Utech 107.* 16 May 1970.
–	14	WIS.: Oneida Co., Big Bearskin Creek, T. 37N, R. 6E, S. 35. *Utech 116.* 18 May 1970.
28	14	WIS.: Oneida Co., Monico. T. 35N, R. 11E, S. 6. *Utech 166.* 16 May 1970.
28 12 II + 4 I 13 II + 2 I	14	WIS.: Sheboygan Co., between Cedar Grove and Oostburg. T. 14N, R. 23E, S. 34. *Utech 109.* 15 May 1970.
–	14	WIS.: Vilas Co., Otto Mielke Lake, T. 40N, R. 7E, S. 20. *Thien 119.* 25 May 1970.

Fig. 2. Karyotype of *Clintonia borealis* (2n = 28). The scale is in microns. The longest pair of chromosomes (1) measured 12.5 microns.

higher mountain zones of eastern North America is possible as such counts have been made from plants collected only at high altitudes. In the Green Mountains of Vermont, Carter and Vogelmann (1968) demonstrated morphological differences in the high elevation populations of *C. borealis* along vertical vegetational gradients. Whether these morphological and chromosomal variation distributions are distinctly associated is still under investigation.

SUMMARY

The genus *Clintonia* (Liliaceae) is composed of six species of herbaceous, perennial plants native to North America and Asia. The chromosome base number for the genus is x = 14.

Plants of *Clintonia borealis* (Ait.) Raf. have chromosome numbers of 2n = 28 or 2n = 32 with many meiotic irregularities. It is suggested that plants with 2n = 32 are found only at high altitudes in eastern North America.

ACKNOWLEDGMENTS

Voucher specimens and photographs of *C. borealis* have been deposited at the Missouri Botanical Garden. The distribution maps are based on herbarium specimens from the following herbaria: CAN, CU, DAO, GH, F, MIN, MO, NO, NY, US, WIS, and WVA. The authors wish to thank the curators for aiding in the study.

The authors also wish to thank Bertha Morimoto for her great assistance and patience in preparing the manuscript.

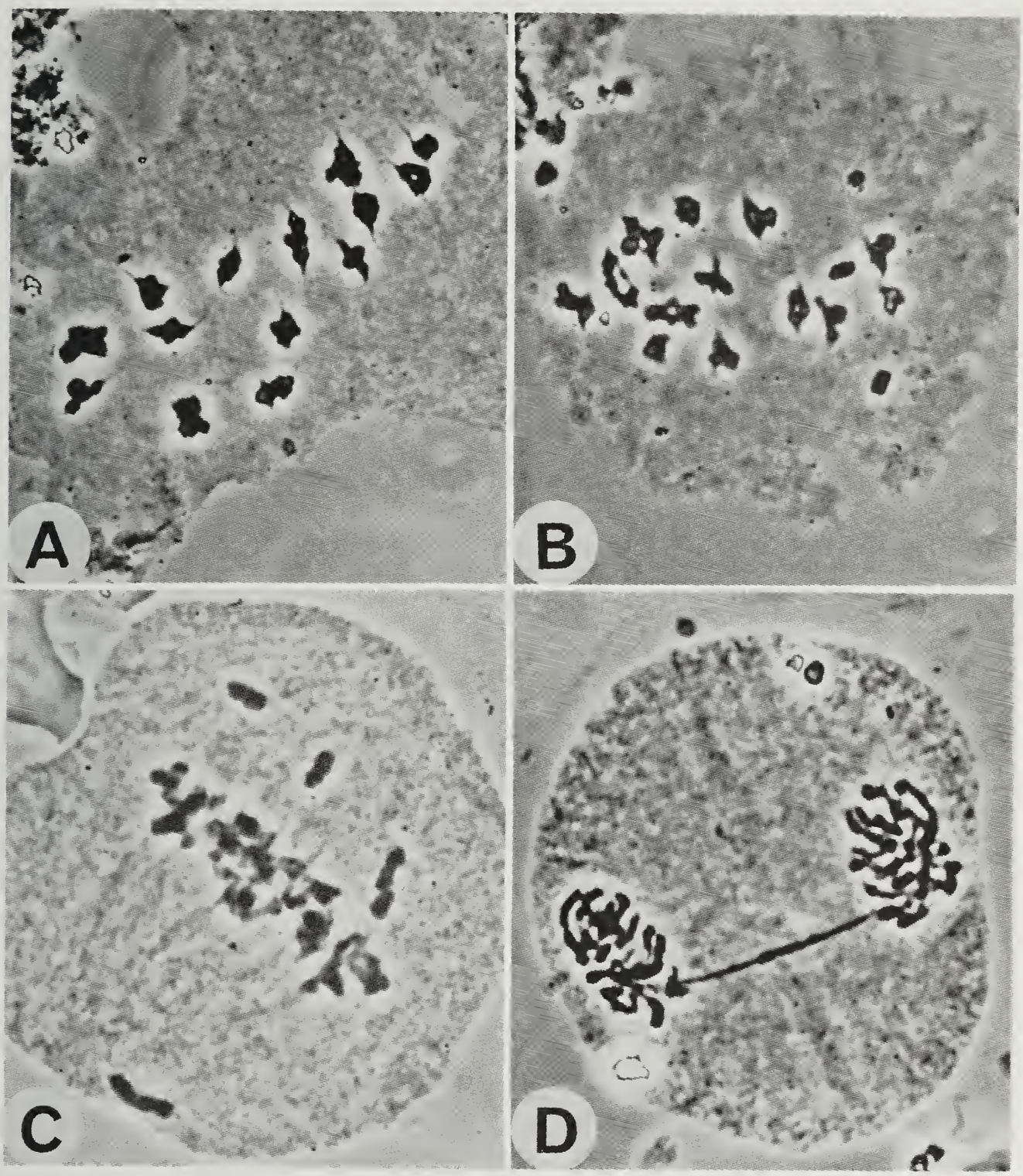

Fig. 3. Meiosis in pollen mother cells of *Clintonia borealis* (2n = 28), ca. ×1200). A. Metaphase I showing 14 pairs of chromosomes. B. Univalents (two dark stained chromosomes) at Metaphase I. C. Metaphase I with bivalents on the cell plate with the univalents moving toward the poles of the cell. D. Anaphase I bridge.

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Review

The NORTH WOODS/THE AMERICAN WILDERNESS. By Percy Knauth and the editors of Time-Life Books. Time-Life Books, New York. 1972. 184 pp. $7.95.

This volume in a new series deals with the area from the shore of Lake Superior northwest to Churchill, Manitoba, on Hudson Bay, and to Great Slave Lake. A map indicates "national parks, provincial parks and other protected wilderness areas"—except for Isle Royale, which is unnamed and unmentioned although colored as part of the "North Woods" covered. The numerous black-and-white and color photos range from quite striking to moderate in quality. They cannot compare with, say, a Sierra Club book—but then, neither can the price! Considerable care seems to have been taken to identify the various plants and animals depicted. The text provides general historical and ecological background; confidence in this material is helped by listing of Sigurd Olson as "The Consultant." Other acknowledgments express particular indebtedness to William O. Pruitt, Jr., a 1952 University of Michigan Ph.D. (zoology) and one of the first biologists to express public concern about some of the "environmental issues." Special topics treated include fire, the life of the beaver, the nature and role of snow, and canoe travel in the wilderness.

—E. G. V.

COMPARATIVE MICROMORPHOLOGY OF SPORE AND ELATER ORNAMENTATION IN *BLASIA PUSILLA*

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INTRODUCTION

Using light microscopy, Leitgeb (1874) and Erdtman (1957; 1965), among others, have observed and described the surface structure of the spores and the pattern of the elater thickenings in *Blasia pusilla,* a liverwort with capsules that ripen in spring. As described by these workers, the spores are weakly granulate and atreme (without apertures). The elaters have bispiral thickenings with the spires often splitting.

Our investigations of spores and elaters of Michigan populations of *Blasia pusilla,* using light and scanning electron microscopy, have confirmed the observations of earlier workers and revealed additional details of fine-structure.

The purpose of this report is to demonstrate the presence of fine-structural ornamentation of the elaters and to report preliminary evidence for morphological and histochemical similarities in the ornamentation of the elaters and spores of *Blasia pusilla.*

METHODS

Mature capsules were collected in May 1971 and May 1972 from fruiting *Blasia pusilla* growing on moist gravelly soil in a roadside ditch, 2.6 miles north of the junction of the private road to the Chase S. Osborn Preserve, and the county road to Homestead, Sugar Island, in Chippewa County, Michigan. Some of the capsules were freeze-dried and stored in a dessicator. The freeze-dried capsules were opened and the spores and elaters were dusted onto the surface of polished aluminum stubs smeared with the natural grease (or oils) from one's finger. The mounted specimens were glow-discharge coated with gold and examined with a Jeolco Model JSM-U3 scanning electron microscope. The acetolysis procedure of Erdtman (1971), and the I-KI, H_2SO_4 method described in Jensen (1962) for cellulose localization were used on the freeze-dried spores and elaters.

OBSERVATIONS AND DISCUSSION

Spore ornamentation in *Blasia pusilla* is clearly portrayed in the series of electron micrographs of increasing magnification (Fig. 1-4). At the lowest

magnification, Fig. 1, the ornamentation appears densely granulate. The curving scar (arrow) denotes the edge of a former contact surface between this spore and another of the original tetrad. This rounded tetrad scar, therefore, marks the boundary between the distal (outer) and proximal (inner) faces of the spore. Otherwise the sculpture pattern of both faces is essentially identical. A portion of the same scar region, viewed at a higher magnification, Fig. 2, further confirms the assertion that there are only minor differences in ornamentation on the distal and proximal faces.

A careful scrutiny of the granulate surface shown in Fig. 3 discloses an irregularity in outline, and a hint of stratification of the individual granules. In Fig. 4, which shows a portion of this surface at a much higher magnification, the aggregate nature of each granule is clearly discernible.

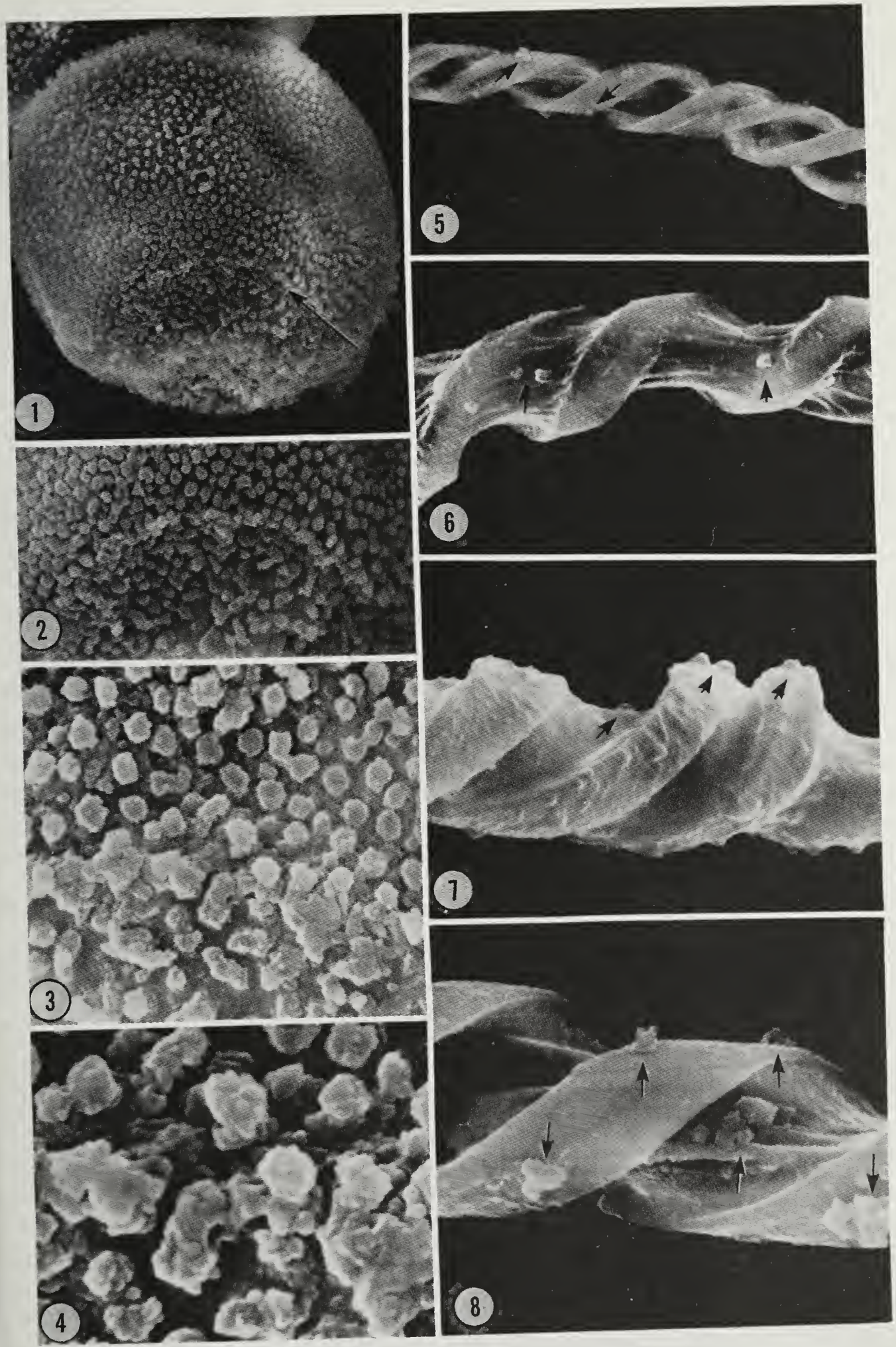
The remaining electron micrographs, Figs. 5-8, depict portions of elaters at similarly increasing magnifications. The spiral thickenings on the inside of the wall are easily identified, since only the non-thickened portions of the wall are slightly collapsed.

Granules are present on both the thickened and non-thickened surface of the wall, and are sparsely distributed. Their form and size, as depicted in Fig. 5, are comparable to those of the individual granules of the spore exine, portrayed in Fig. 1, at the same magnification. This concept of homology in size and form is further substantiated by a comparison of Fig. 6 and Fig. 2 (both at the same magnification). A portion of an elater from another capsule is depicted in Fig. 7. Here, in addition to the knob-like granules (arrows), the tendency for a low-profile sculpturing of the wall is apparent. Together, Fig. 7 and Fig. 8 show the variation that exists within the pattern of elater ornamentation. In Fig. 8, the electron micrograph demonstrates that the granules (arrows) may occur either singly or in clusters, and suggests that they possess an aggregate nature similar to that of the granules on the spores.

These electron micrographs (Figs. 5-8) demonstrate the existence of micromorphological features of the elaters of *Blasia,* which bear a strong resemblance in size and form to the granules on the exine of its spores. Preliminary evidence for chemical identity of the elater granules with those of the spore exine (as sporopollenin) is based on two microchemical tests.

The I-KI, H_2SO_4 test for cellulose demonstrates that the granules of the

Figs. 1-8. Electron micrographs of spore and portions of elaters of *Blasia pusilla.* Fig. 1. Spore; the arrow denotes the boundary between proximal and distal faces, 1,800X. Fig. 2. Portion of tetrad scar region (same spore), 3,000X. Fig. 3. Portion of spore surface shown in Fig. 2, photographed at a higher magnification. Note the irregular shape and aggregate appearance of the granules, 6,000X. Fig. 4. Portion of spore surface shown in Fig. 3, photographed at a higher magnification to show stratification and stacking in the individual granules, 12,000X. Fig. 5. Portion of an elater showing bispiral thickening and surface ornamentation (arrows), 1,800X. Fig. 6. Portion of another elater showing surface knob-like granules (arrows), 3,000X. Fig. 7. Portion of a third elater showing knob-like granules (arrows), as bold features of an overall, diffuse pattern of surface sculpturing, 6,000X. Scanned at 10,000X. Fig. 8. Portion of the elater depicted in Fig. 5 photographed at a higher magnification, demonstrating clusters of granules (arrows), 12,000X.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elater surface are not cellulosic. Observing a group of spores and elaters under the light microscope during the course of this test, one sees the elater wall and its spiral thickening stain blue as the acid partially hydrolyzes the cellulose. The brownish staining coloration of the iodine in the spore exine and in the granules of the elaters stands out distinctly against this blue background. As the acid continues to work, the cellulose portions of the spore and elater walls gradually dissolve, and all that remains are the brown stained spore exines and loose collections of brown stained granules marking the former locations of the elaters.

The chemical identity of the spore exines and elater granules is further suggested by acetolysis. However, more sophisticated techniques are needed to provide rigorous proof that the collection of minute granules, which are found mixed with the spore exines after acetolysis, were once located on the walls of the elaters.

Horner, Lersten, and Bowen (1966) have presented evidence for *Riccardia pinguis* (and summarized the findings of earlier workers for other liverworts) that the pattern of the mature spore exine is endogenous (under control of the spore protoplast) in origin. In *Blasia,* it would be of interest to determine if the patterns of ornamentation of the unicellular haploid spore and, in particular, the diploid single-celled elater have similar origins.

CONCLUSIONS

The scanning electron microscope, used as a research tool in the investigation of spore and elater ornamentation in *Blasia pusilla,* has provided the evidence for morphological similarity, and thus brought us a step closer to answering the question inherent in the observations of Erdtman (1957; 1965) regarding elater ornamentation in the liverwort *Plagiochasma.* Developmental studies of spores *and elaters* of liverworts are indicated for a better understanding of the site of synthesis and the mechanism of sporopollenin deposition.

ACKNOWLEDGMENTS

We thank Mr. Larry Allard for technical assistance, and Mr. Louis Martonyi and Photographic Services of the University of Michigan for their photographic work.

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Publications of Interest

From time to time we call attention, under this heading, to new publications which might be of particular interest to some of our readers but which, because of less explicit geographic or botanical orientation, do not qualify for regular review or inclusion in the listings of new literature relating to Michigan botany. All annotations are by the Editor unless ascribed to another.

HOW TO BUILD AND SAVE BEACHES AND DUNES: Preserving the Shoreline with Fencing and Beachgrass. By John A. Jagschitz & Robert C. Wakefield. Rhode Island Agricultural Experiment Station Bull. 408 (Marine Leaflet Series No. 4). 1971. 12 pp. Includes full details on use of *Ammophila breviligulata* for sand stabilization on Atlantic and Great Lakes shores, with illustrations.

THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY. By Malcolm F. Baldwin. The Conservation Foundation (1717 Massachusetts Ave., N.W., Washington, D.C. 20036). 1970. 52 pp. $1.00. This is a "report on the social and environmental effects of off-road vehicles, particularly snowmobiles, with suggested policies for their control."

PUBLICATIONS OF THE GEOLOGICAL SURVEY 1962-1970. U.S. Government Printing Office. 1972. 586 pp. Contains full listings of publications by series (not including standard topographic maps), plus analytical index which includes geographic entries. This supplement and the basic 457-page original catalog, Publications of the Geological Survey 1879-1961, published in 1964, are available on application to the U.S. Geological Survey, Arlington, Virginia 22202.

THE NATURAL VEGETATION OF OHIO IN PIONEER DAYS. By Robert B. Gordon. Bulletin of the Ohio Biological Survey n. s. 3(2). 1969. 109 pp. $3.50. Somehow we have neglected to call attention to this full explanation intended to accompany the map already noted in Mich. Bot. 6: 70. 1967. Excellent photographs, historical notes, and descriptions of the different vegetation types are included. Correlations with climate and geology are suggested (the latter more fully discussed by Jane L. Forsyth in Ohio Jour. Sci. 70: 180-191. 1970). The large color map ($1.00) and this subsequent bulletin are available from O.S.U. Publications Sales & Distribution Office, 2500 Kenny Road, Columbus, Ohio 43210.

AN ILLUSTRATED TAXONOMY MANUAL OF WEED SEEDS. By Richard J. Delorit. Agronomy Publications, River Falls, Wisconsin. 1970. 175 pp. $5.95 (plastic), $7.75 (hardcover). Despite its odd title (I know of nothing else termed a "taxonomy manual"), this work appears to be a very useful identification guide, with key to 192 weeds based on their seeds (or other small propagules, such as achenes, grass spikelets, etc.). All species are illustrated by excellent, clear color photographs—although the paper on which they are printed, being coated on one side only, unfortunately curls badly under some humidity conditions, so the work will not lie flat.

CANOEIST SUGGESTIONS FOR STREAM MANAGEMENT IN THE MANISTEE NATIONAL FOREST OF MICHIGAN. By Michael J. Solomon and Edward A. Hansen. U.S. Department of Agriculture, Forest Service Research Paper NC-77. 1972. 10 pp. Users of the Pine River enjoyed rapids and wild, natural shoreline; objected to littering and crowding; seemed little concerned about erosion and a dam.

LANDSCAPE FOR LIVING. The Yearbook of Agriculture 1972. U.S. Department of Agriculture, 1972. 376 pp. $3.50. This year's volume in the annual series includes some handsome color pictures of plants and considerable material on gardening and landscaping in the form of short articles under the general categories of "Plants in the Living Environment," "Matching Plants to the Environment," "Selecting and Protecting Plants," "Searching For, Breeding, and Propagating New Plants," "Understanding

Plant Growth," "Plants in Action," "Who Can Help," and "Planning for Growth Centers." Citizens who desire a copy promptly, and without cost, may request one from their congressmen instead of ordering from the Superintendent of Documents.

ARCTIC ADAPTATIONS IN PLANTS. By D. B. O. Savile. Canada Department of Agriculture Monograph 6. 1972. 81 pp. A broad survey, with substantial list of references, dealing with winter and summer survival and dispersal in the Arctic, including some material on cryptogams as well as flowering plants. Although the northern Great Lakes region is hardly arctic (despite occasional impressions!), many readers with boreal interests will be pleased to know of this useful presentation, which is available from Information Division, Canada Department of Agriculture, Ottawa K1A OC7.

INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE. Prepared and edited by F. A. Stafleu (chairman), E. G. Voss (secretary), and members of the Editorial Committee. International Association for Plant Taxonomy (Reg. Veg. Vol. 82). Utrecht, 1972. 426 pp. $20.00 ($13.50 for IAPT members). The Code, as revised at the XI International Botanical Congress in Seattle, 1969, with French and German translations, appendices (including updated lists of conserved names), and index.

THE COMPLEAT NATURALIST. A Life of Linnaeus. By Wilfred Blunt, with the assistance of William T. Stearn. Collins, London. 1971. 256 pp. £3.50 [= ±$8.40]. LINNAEUS AND THE LINNAEANS. The spreading of their ideas in systematic botany, 1735-1789. By Frans A. Stafleu. International Association for Plant Taxonomy (Reg. Veg. Vol. 79). Utrecht, 1971. 386 pp. $17.60 ($11.80 for IAPT members). These two substantial volumes on Linnaeus are quite different and each in its way will appeal to botanists and botanical historians. Blunt's colorful volume is copiously and beautifully illustrated with photographs, drawings, reproductions, and marginal vignettes bearing, at least remotely, on Linnaeus. This is a very readable general biography with full details on the life, health, travels, and accomplishments of the great Swede. Stearn's authoritative appendix discusses Linnaean classification, nomenclature, and method. Stafleu's work is much less copiously illustrated, but expounds upon Linnaeus' ideas and their spread and development among his students and followers. This treatise is thus an important contribution to the history of ideas, not systematic botany alone, in the mid-eighteenth century.

MAMMALS OF THE GREAT LAKES REGION. By William Henry Burt. University of Michigan Press, Ann Arbor. 1972. 246 pp. $2.50. This is a new printing, in the Ann Arbor Paperbacks series, of a work first published in 1957 and still available in that clothbound edition at $6.95. After a comprehensive introduction, the species are described, with sketches and distribution maps. Directions for preparing specimens, an artificial key, and technical data precede the index. A useful volume for field use.

PLANTS IN THE SERVICE OF MAN: 10,000 Years of Domestication. By Edward Hyams. Dent & Sons, London. 1971. 222 pp. £2.95 [= ± $7.10]. A popular account, by a well known gardening authority, treating the history of domestication of the diverse botanical sources from which we derive grains, fruits, vegetables, beverages, fibers, stimulants and narcotics, spices and incenses, and cane sugar. There are 33 ancient and modern illustrations of plants and prehistoric artifacts depicting them. The endpapers are maps showing graphically the origins in Old and New Worlds of many familiar and useful cultivated plants.

REVIEWS

WILDFLOWERS AND WEEDS: A GUIDE IN FULL COLOR. By Booth Courtenay and James Hall Zimmerman. Van Nostrand Reinhold Co., New York [1972]. xl + 144 pp. $10.95.

Although its title contains no such indication, *Wildflowers and Weeds* is a regional wildflower guide, designed for use in "the Great Lakes region of the United States and Canada." Because of this geographic limitation, the book is able to include a more thorough representation of the flowering plants of this region than most wildflower guides designed for a larger portion of the continent. This is basically a guide to herbaceous plants, although some shrubby ones, mostly Ericaceae, are included. Such groups as the pondweeds, grasses, sedges, duckweeds, and rushes are not covered.

Wildflowers and Weeds is a very compact book, and its pages, binding, and even its plasticized dust jacket all appear to be durable as well as attractive. At $10.95 ($12.50 in Canada), however, it hardly seems to constitute the best bargain available in wildflower guides for this region.

The 655 color photographs constitute virtually the sole basis for the identification of species. Only supplementary comments, mostly on habitat, are provided in the text. Attention was given not only to photographic quality, which appears to have been very good in most of the original slides, but also to illustrating those aspects which are most useful in field identification.

When up to nine illustrations are grouped on one 5 X 8 inch page, it is essential that the several impressions involved in the printing of a color plate be precisely aligned with one another. The majority of the 136 pages of color in the reviewer's copy are adequate in this respect, and some transmit the original sharpness of the slides superbly. The alignment on ten pages is very poor, however, and it could definitely have been better on a dozen or so more. Trueness of color ranges from adequate to excellent in the majority of the photographs.

In lieu of a key, a series of charts is presented as a guide to plant families. These charts, unfortunately, seem more likely to confuse than to help the beginner. "Flowers in dense heads," for example, leads only to the Compositae; the route to *Monarda* or *Dipsacus* is via "Flowers not in dense heads." Likewise, "Flowers tubular" leads to any dicot with united petals, although rotate corollas such as those of *Lysimachia* species might hardly seem to be "tubular" to the uninitiated. A more laudable feature of the introductory pages is the relatively extensive discussion of plant habitats and their significance in plant identification.

Commendably, species have been grouped according to genus and family. The sequence of families in the aforementioned charts is the basis of their arrangement in the book. This sequence is somewhat similar to the familiar system of Engler and Prantl, but occasional drastic departures may surprise the experienced naturalist.

Scientific nomenclature adheres strictly to Gleason and Cronquist's *Manual of Vascular Plants.* While this practice doubtless eases the transition from introductory guides to manuals, it is unfortunate that it perpetuates and proliferates the use of such names as *Cubelium.* The selection of English names, in most cases, has sensibly favored those which are widely used and consistently applied, or, when no truly common name existed, unambiguous anglicizations of the scientific names. A few choices, however, such as "Axseed" for *Coronilla varia,* rather than the widely publicized name "Crownvetch," seem to be less than optimal, and a few fanciful creations, such as "Side Bells" for *Pyrola secunda,* appear unlikely to facilitate communication.

Inaccuracies appear to be very few. The illustration purportedly of *Fragaria virginiana* is obviously of *F. vesca*; and *Samolus parviflorus,* contrary to its description, actually has alternate leaves. *Chrysopsis* and *Geocaulon* are listed in the index but are not mentioned in the text.

—James S. Pringle

DESMIDIALES PART I. Saccodermae, Mesotaeniaceae. By G. W. Prescott, Hannah T. Croasdale, & W. C. Vinyard. North American Flora II (6). 1972. 84 pp. $4.75.

Perhaps the most fascinating group of algae which are limited to freshwater situations, the desmids have always attracted many amateur or semi-professional students, but few who have had more than a very local experience with the group in America. Only once before has a survey really wide in its range been published, that of the Rev. Francis Wolle on the United States species, in 1892. Undoubtedly Fr. Irénée Marie has been most prolific in publishing, but by intensively studying the Québec flora, rather than ranging widely. Other leading desmidiologists have now, fortunately, begun a detailed catalog of flora of near continental scope, limited however to the waters north of Mexico. Dr. G. W. Prescott (formerly Michigan, now Montana), Dr. H. T. Croasdale (Massachusetts and New Hampshire) and Dr. W. C. Vinyard (Oklahoma, now California) have begun issuing this flora from the New York Botanical Garden. Dr. Prescott, with his long experience with the Michigan flora and other studies in various parts of the Americas, Dr. Croasdale with long New England and much Alaskan experience, and jointly with the famous Finnish specialist, Dr. Rolf Grönblad and the engineer-amateur A. M. Scott extensive studies on collections from various exotic floras, bring mature experience with these plants to support the enthusiasm of the younger Dr. Vinyard.

This first part deals with the least specialized genera. While the descriptions are, perhaps, rather brief, these are supported by very comprehensive, clear drawings. The most important bibliographic citations are given, and the distribution is brief, since as desmids are very wide-ranging plants, particularly in "acid" waters, detailed localities would hardly be significant. Naturally Michigan, Alaska, and Québec figure largely. This issue contains an extensive bibliography, ranging beyond those papers dealing strictly with North America, for which alone a degree of completeness is claimed. This work as it continues will, undoubtedly, greatly assist studies of our freshwater vegetation and limnology in general. There are, unfortunately, a greatly excessive number of typographical errors and inconsistencies which closer editing and proofreading should have eliminated, and it is hoped that later parts will receive closer attention in these matters.

—Wm. Randolph Taylor

VAUCHERIACEAE. By John L. Blum. North American Flora II (8). 1972. 64 pp. $2.75.

The genus *Vaucheria* is one of the widest-spread of algae, and notable for having a few marine species as well as many in freshwater habitats, from frigid to torrid areas and around the world. Blum for the first time brings the genus into focus for North America, reporting over 40 species known to be present there, double the list recognized by F. S. Collins (Green Algae of North America, Tufts Coll. Stud. 4, 1918, *et seq.*). Wide though the coverage is, thanks to the field work of Nichols, Prescott, and others, Michigan reports are substantial.

This is a thoroughly documented account, involving careful reassessment of older species, recognition of much synonymy, and designation of many names and records which could not be confirmed from American material. In some cases current concepts of certain species fail to correspond in essentials with type materials supporting their names, so several very familiar species names are transferred or discarded. Much useful discussion of species interrelationships is given. The data in the descriptions are primarily based on American material and not carried over from old reports.

The genus *Vaucheria* being nearly unique, it is not surprising that its relation to others of quite different morphology in higher categories of classification may seem debatable, but within the genus the grouping in sections, rather traditional, still seems helpful. However, no explanation is given for the appearance of the generic lectotype *V. disperma* DC., which is reduced to synonymy under *V. canalicularis* (L.) Christ., in a section *Anomalae* with *V. cruciata* as type, when we would expect it to typify a section *Vaucheria* (Internatl. Code Bot. Nomencl. Art. 22). It is curious that so little information

about the aplanospores is given, even in descriptions of species where they are well known (as *V. bermudensis* T. & B.), though less curious that the zoospores are not mentioned, since they might be in bad condition in herbarium material. However, information on these propagative structures would be of interest in considering the ecological potentials of the species.

The monograph is adequately, if simply, illustrated. The genus offers none of the opportunity for elegance in portrayal shown by the desmids, and the often confused clustering of the oögonia and antheridia makes for very difficult graphic analysis. This is carefully explained and standards for mensuration are set up. The genus offers peculiar difficulties respecting preparation of study and herbarium material, and so full directions are given for proper treatment.

The bibliography places journal references before the titles of articles but the references are very carefully done. With this list there is an analytical catalog of all serials important to *Vaucheria* studies. In these and in many other points this monograph differs in style from the first part of that on the desmids, but not from other parts of the North American Flora hitherto published.

–Wm. Randolph Taylor

THE NORTH AMERICAN SPECIES OF PSATHYRELLA. By Alexander H. Smith. Memoirs of The New York Botanical Garden Vol. 24. 1972. 633 pp. $35.00.

When confronted with a 3½-pound monograph treating in detail on 633 pages (including 95 plates) more than 400 recognized species (well over half of them new) for a single mushroom genus in North America (especially Michigan and the Pacific Northwest), there is little this reviewer can do except refer to the well known taxonomic and photographic reputation of the author and call attention to the long-awaited publication of a work 37 years in preparation! And perhaps to deplore the fact that so potentially useful a volume, with superb illustrations and detailed instructions for study, is likely to come into the hands of very few individuals, whether professional mycologists or Dr. Smith's large non-professional following of mycophiles, because of the burden of a $35 pricetag for a paperbound publication.

It is a pleasure to see a work by a cryptogamic botanist who has attempted so thoroughly to follow the International Code of Botanical Nomenclature (although it is not clear why a new combination is made for subgenus *Psathyroides* when a name already in that rank is cited in synonymy). Those who delight in distributional details may regret the usual absence of more precise localities than states, except for types of new taxa, where frequently the county–so often used as a mapping unit–is not mentioned. Persons unfamiliar with Michigan small towns, for example, may need to spend some time locating Chelsea, Highland, New Hudson, South Lyon, or Vanderbilt. The Latin diagnosis for one new species (336) says it was collected near Big Bay, which is in Marquette County, but the English makes clear that the locality was actually 17 miles to the west, in Baraga County. If dates had been given with type collections, it might have been clear whether "Botanical Gardens, University of Michigan" (63) refers to the "new" site (since 1961) near Dixboro or to the previous site in Ann Arbor.

Not least among the achievements of the author in producing this "introduction" to so large a genus is managing to apply 414 different specific epithets (not including synonyms)!

–E. G.V.

WILD PLANTS IN FLOWER: THE PRAIRIE–Swell and Swale. By Torkel Korling. [Published by the author,] Dundee, Illinois. 1972. [22] pp. + 63 col. pl.

Admirers of the superb wildflower photography of Torkel Korling will be quick to welcome this beautifully printed first number in a "habitat series" of pocket-sized books (4½ × 6½ inches)–the first real effort to produce in large quantity and hence at a low price a collection of his pictures. The photos appear in a general sequence from spring to fall, and often show a bit of another species (never identified) which is the main subject in a different one (note especially the "build-up" in plates 25 and 26 to the *Silphium* on plate 27). The wrap-around cover is a fine scene of *Habenaria leucophaea, Veronicastrum, Phlox,* and other wet-prairie species. The plates are preceded by an all-too-brief essay "What Is a Prairie" by Robert F. Betz and a table giving for each main subject its family, average height in inches, habitat, and blooming season in the latitude of Chicago. There is no further descriptive information nor other help in identification–not even statements of overall distribution for any of the species that might have distinctive patterns. The plants here shown may all "be found in the lake shore prairies of the Illinois-Wisconsin border, in profusions of bloom that serve well to remind us of other prairies long vanished." A later volume is in preparation for the mixedgrass prairies of the high plains. One might hope that some of the grasses and sedges will then warrant illustration, or at least mention when as well shown as *Rhynchospora capillacea* on plate 37 or *Andropogon gerardii* on plate 39 of the present volume.

Plate 52 surely shows *Oxypolis rigidior* and not *Sium suave*; there are typographical errors in scientific names under 3 plates (28, 43, & 49) and in one common name (11).

Books like this should do much to awaken the non-botanical public to the beauties of the dwindling wild places and even to rekindle in many botanists some of the appreciation for plants by which we would like to think they have been motivated.

–E. G. V.

FORESTS OF LILLIPUT: The Realm of Mosses and Lichens. By John H. Bland. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1971. xxiv + 210 pp. $7.95.

Any book with such an apt and fetching title or one so well written and attractively produced cannot be all bad. In its beauty it mirrors a magical splendor that is commendable in a book for Everyman. I especially commend the elfin charm and original style of the line drawings introducing each chapter. However, much as I enjoyed reading and rereading the book, I must point out that it presents a fair amount of error too–and even Ruskin should not be allowed gross inaccuracy when the price is $7.95.

The photographs are technically acceptable, even though the mosses have the look of rewetted sods, but it is surprising to find so many of them mislabeled. The legends for *Cladonia verticillata* and *C. gracilis* are interchanged. *Ramalina calicaris* is probably not present in either photograph so labeled. A species of *Atrichum* appears as *Polytrichum piliferum.* The two photographs of *Marchantia* show the conspicuous pores of *Conocephalum. Rhodobryum roseum* looks suspiciously like *Mnium affine,* and *Sphagnum squarrosum* is certainly not correctly named.

A fertilized egg of a moss is a zygote, but never a zygospore! I doubt whether a Florentine merchant discovered the use of lichen dyes while relieving himself on the shore of the Levant some centuries ago. It now takes months of maceration in ammonia, or stale urine, to make a usable extract of such "orchil" dye!

After hours of searching through books on heraldry, I found that it is not true that the Knight's Plume Moss (*Ptilium crista-castrensis*) is figured on the coat of arms of John the Gaunt or his descendants, the Dukes of Lancaster. Similar-looking plumes are featured there and in numerous other devices of heraldry, but not mosses!

I could document the errors at length, and yet I recommend this book as interesting and fun to read. It should be judged as poetry rather than prose. Perhaps *Dichtung und Wahrheit* or truth and beauty can be separated after all. But would it not have been better if the book had been purged of error before publication?

–Howard Crum

MICHIGAN PLANTS IN PRINT
New Literature Relating to Michigan Botany

A. MAPS, SOILS, GEOLOGY, CLIMATE

Krefting, L. W., H. L. Hansen, & M. P. Meyer. 1970. Vegetation Type Map of Isle Royale National Park. U.S. Dep. Interior, Bur. Sport Fish. & Wildl. 1 folded sheet in pocket. [Plain uncolored map at scale of 1:31,250 showing boundaries of types identified by symbols for the various dominant woody species (or rock outcrop); drafted in 1964 and trails apparently indicated as of that year.]

Strommen, N. D. 1971. Climate of Michigan by Stations. 2nd rev. ed. Michigan Weather Service. n. p. $1.00. [This plastic-bound volume includes representative data and narrative summaries for 98 stations, including at least one in all but 10 counties of the state (it is unfortunate there is no station on Isle Royale, which would doubtless record significantly different data from those of the nearest station, at Houghton). This vast assemblage of data is available very reasonably from Michigan Weather Service, 1405 S. Harrison Road, East Lansing 48823; the sheet for an individual station is free upon request. A brief general introduction on "Climate of Michigan" repeats some odd or at least old errors: the highest point in Michigan is not 2023 feet in Ontonagon Co. (it is 1980 feet, in Baraga Co.); and surely there are not two entire counties which lack lakes! Some other general information also needs to be taken with a bit of skepticism: Pellston, one of Michigan's best known weather stations, is not in southwest (or any other part of) Charlevoix Co., nor is it 12 miles from Grand Traverse Bay. The Ann Arbor station is not "now" 800 feet north of the East University Branch Post Office, as that branch was discontinued May 22, 1960–even before the 1961 relocation of weather instruments.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Blum, John L. 1972. Vaucheriaceae. N. Am. Flora II (8). 64 pp. $2.75. [See review, pp. 136-137. Several of the species are cited from Michigan, usually without further locality data (type locality of *V. taylorii* is Beaver Island, and several of the figures are of material from that island). Overall, appears to be a much more careful treatment than the recent one on Desmidiales in the same series. Species in the keys are not only numbered in sequence but page numbers on which they are described are also cited, whereas there are no such aids in the desmid work. It does seem unnecessary to use a unique set of symbols for herbaria (p. 32), when the Index Herbariorum is so widely accepted internationally.]

Hawksworth, Frank G., & Delbert Wiens. 1972. Biology and Classification of Dwarf Mistletoes (Arceuthobium). U.S. Dep. Agr., Forest Serv., Agr. Handb. 401. 234 pp. $4.50 (Govt. Printing Off.). [A thorough taxonomic revision, with illustrations including distribution maps and color photos of all 28 species. *A. pusillum* is the only species in Michigan, and only a Himalayan one has smaller shoots. Half a dozen typographical errors in locality names mar the citations of Michigan records. The authors justifiably point out that an old report from White Cloud needs verification. No collections are known within 75 (not 50, as they say) miles of there, although they have mapped an unsubstantiated but presumably reliable report by C. A. Davis from southeastern Wexford Co. Altogether, a handsome, sturdily bound volume, with keys, excellent illustrations, index to exsiccatae, etc. Literature fails to cite previous report on Michigan (Mich. Audubon Newsletter Nov.-Dec. 1967).]

Krefting, Laurits W., Forrest B. Lee, Philip C. Shelton, & Karl T. Gilbert. 1966. Birds of Isle Royale in Lake Superior. U.S. Dep. Interior, Bur. Sport Fish. & Wildl. Spec. Sci. Rep.–Wildlife No. 94. 56 pp. [Includes two pages of background information, four pages describing vegetation and bird distribution as related to habitats, and eight excellent photographs of representative habitats.]

Prescott, G. W., Hannah T. Croasdale, & W. C. Vinyard. 1972. Desmidiales Part I. Saccodermae, Mesotaeniaceae. N. Am. Flora II (6). 84 pp. $4.75. [See review on p. 136. Many taxa are cited from Michigan, but without further locality data. The authors' repeated usage of the word "ecology" to mean "habitat," or merely cited material, or even otherwise, is worse than the too-common current misunderstanding of that word in the popular press. *Netrium digitus* var. *scottii* f. *minus* is described as new from Michigan, Brazil, and Mississippi, but is invalidly published as no type is designated. This is just as well, however, for earlier on the same page is described another f. *minus* in the same species and two such epithets would have violated Art. 64 of the Code. Furthermore, description of *N. minus* as a species, while not invalid, violates Rec. 24A of the Code. Even to a non-algologist, this part of N. Am. Flora appears to contain more typographical, editorial, and nomenclatural errors and irregularities than any previous part of this once distinguished series. The inside front cover instructs that this issue be cited as "N. Am. Flora II. 7"—a practice which could only cause confusion since this part is in fact No. 6, not 7.]

Zimmerman, James H. (ed.). 1972. Proceedings of the Second Midwest Prairie Conference. 242 pp. $6.00 (U. Wis. Arboretum). [Includes a wide diversity of brief papers and abstracts presented in 1970 at the University of Wisconsin, including ones by Edward Scharrer, "Relic Prairies of Southwestern Michigan" (pp. 9-12), and Paul W. Thompson, "The Preservation of Prairie Stands in Michigan" (pp. 13-14). "Microevolution of Canada Mayflower by Climatic Change as Shown by Geographic Distribution Indicating Post-glacial Prairie Extension" by David F. Grether (pp. 188-190) includes a map showing percentage of pubescent plants (*Maianthemum canadense* var. *interius*) in grid of 120-mile squares, based on examination of herbarium specimens which must have included relatively little Michigan material; e.g., a strange loop on range of 100% glabrous plants southward onto the Keweenaw Peninsula where in fact pubescent plants are as frequent as elsewhere in the state and were described as a new subvariety by Farwell.]

C. JOURNAL ARTICLES

Blum, John L. 1971. Notes on American Vaucheriae. Bull. Torrey Bot. Club 98: 189-194. [*V. taylorii,* named for Wm. Randolph Taylor, described as new from Beaver Island.]

Bowler, Peter A. 1972. The distribution of four chemical races of Cladonia chlorophaea in North America. Bryologist 75: 350-354. [Maps show localities for three of the races in Michigan.]

Delgadillo M., Claudio. 1971. Phytogeographic studies on alpine mosses of Mexico. Bryologist 74: 331-346. [Range of *Orthotrichum pallens* said to include Michigan.]

Faust, W. Zack. 1972. A biosystematic study of the Interiores species group of the genus Vernonia (Compositae). Brittonia 24: 363-378. [Map shows four localities for *V. missurica* in the southern Lower Peninsula and *V. michiganensis* is included in the synonymy of this species.]

Grether, David F. 1972. [See under Zimmerman in section B above.]

Marty, Robert. 1972. The economic impact of Hypoxylon canker on the lake states resource. Pp. 21-26 in Aspen: Symposium Proceedings, North Central For. Exp. Sta., U.S. For. Serv. Gen. Tech. Rep. NC-1. [Includes summary data on Hypoxylon canker infection, denudation, and impact on aspen in Michigan, Wisconsin, and Minnesota.]

Miller, Orson K., Jr. 1972 ["1971"]. The genus Gomphidius with a revised description of the Gomphidiaceae and a key to the genera. Mycologia 63: 1129-1163. [Three species cited from Michigan without further locality data.]

Petersen, Ronald H. 1972. Notes on clavarioid fungi. XII. Miscellaneous notes on Clavariadelphus, and a new segregate genus. Mycologia 64: 137-152. [Three species cited from Michigan localities.]

Pringle, James S. 1971. Taxonomy and distribution of Clematis, sect. Atragene (Ranunculaceae), in North America. Brittonia 23: 361-393. [Distribution map for *C. occidentalis* (widely known as *C. verticillaris*) includes dots for Upper Peninsula localities.]

Raven, Peter H., & David P. Gregory. 1972. Observations of meiotic chromosomes in Gaura (Onagraceae). Brittonia 24: 71-86. [Includes counts on *G. longiflora* from Jackson Co.]

Reed, Frank C., & S. N. Stephenson. 1972. The effects of simulated herbivory on Ambrosia artemisiifolia L. and Arctium minus Schk. Mich. Academ. 4: 359-364. [Study in an abandoned field on the M.S.U. campus.]

Rich, Peter H., Robert G. Wetzel, & Nguyen Van Thuy. 1971. Distribution, production and role of aquatic macrophytes in a southern Michigan marl lake. Freshwater Biol. 1: 3-21. [Study in Lawrence Lake, Barry Co.; cf. Mich. Bot. 9: 3-9. 1970.]

Schaarer, Edward. 1972. [See under Zimmerman in section B above.]

Schuyler, Alfred E. 1972. Chromosome numbers of Scirpus purshianus and S. smithii. Rhodora 74: 398-402. [*S. purshianus* f. *williamsii* from Kalamazoo Co. gave count of n = 19 and the two forms of this species seem to show habitat differences in southwestern Michigan; *S. smithii* (from elsewhere) has n = 20.]

Scott, William W., & Aaron H. O'Bier. 1962. Aquatic fungi associated with diseased fish and fish eggs. Progressive Fish-Culturist 24: 3-15. [Includes record of *Saprolegnia delica* on cisco from Northville, Michigan.]

Soper, James H., Edward G. Voss, & Kenneth E. Guire. 1972. Distribution of Primula mistassinica in the Great Lakes region. Quart. Am. Primrose Soc. 30: 108-112. [Reprinted from Mich. Bot. Vol. 4, 1965, with addition of photos from New York and reference to an inland Michigan occurrence in Otsego Co. subsequent to the distribution map.]

Thompson, Paul W. 1972. [See under Zimmerman in section B above.]

Urbatsch, Lowell E. 1972. Systematic study of the Altissimae and Giganteae species groups of the genus Vernonia (Compositae). Brittonia 24: 229-238. [Distribution map shows *V. gigantea* ssp. *gigantea* in southwest corner of Lower Peninsula.]

Vitt, Dale H., Norton G. Miller, & Ardith B. Johnsen. 1971. Bryophytes new to Arizona. Bryologist 74: 499-501. [Two boreal species noted as ranging south in the east to Michigan.]

D. HISTORY, BIOGRAPHY, EXPLORATION

Whittaker, Alfred H. 1972. Zina Pitcher, MD 1797-1872. Mich. Medicine 71: 1038. [Brief biographical sketch, with no reference to Pitcher's botanical activities. Cover of the issue of Michigan Medicine (December, 1972) has a fine portrait of Pitcher.]

XII International Botanical Congress

The XII International Botanical Congress is to be held in Leningrad, U.S.S.R., June 23-30, 1975. The sessions of the Nomenclature section will be held June 20-23. "A Suggested Scientific Programme," with return card, has been issued, and the First Information Circular will be sent this summer to those who have mailed the return half of their card (requested by March 1) to the scientific secretary of the Organizing Committee, N. S. Snigirevskaya, Komarov Botanical Institute, 2 Prof. Popov Street, Leningrad 197022, U.S.S.R.

Field trips are, as usual, planned to precede and follow the Congress and will acquaint visiting botanists with as many interesting and unique features of the flora and vegetation of the U.S.S.R. as possible. Some specialized trips for phycologists, lichenologists, bryologists, and palaeobotanists are also planned.

THE MICHIGAN BOTANIST is distributed not only to a considerable number of individual and institutional subscribers domestically and abroad, but also to all members of the Michigan Botanical Club, an organization composed in large part of non-professionals with concerns for conservation and nature study as well as the local flora. (Total paid circulation exceeds 1000). Considering the range of interests among members and subscribers, we seek to include (in each year if not each issue) the widest possible range of subject matter in regard both to the entire plant kingdom and to branches of the field of botany.

Articles should, in general, include some new botanical information, and should pertain to the Upper Great Lakes region. Not acceptable are manuscripts of primarily literary nature (including all poetry and articles of an "editorial" orientation). Notes on techniques useful to the teacher and hobbyist are welcomed, as is material of biographical and historical nature.

To promote clarity to non-technical readers (without sacrifice of accuracy and precision), such means are encouraged as illustrations, inclusion of a generally accepted "common name" (when such exists) at least once in the title or text of any article devoted to consideration of one or a few species, and introductory material placing the author's studies in perspective and briefly indicating their significance. Summaries, especially of long or complex papers, are desirable.

Manuscripts should be submitted to the editor in chief and are considered on their botanical merit and clarity of presentation; their acceptability is judged without special regard for repetition of authors, length, or prospect of subsidies. All manuscripts are subject to advisory review by botanists prepared to evaluate not only their content but also their suitability for this journal. Manuscripts are ordinarily published in the order of acceptance, with allowance as necessary for maintenance of diversity within our space limitations. In the interests of diversity, acceptable articles occupying more than 10 printed pages can be published only if divided into two or more issues or if the necessary additional pages can be subsidized (present charge is $15.00 per page). Subsidy of the entire cost of an acceptable article will permit its publication without delay, and authors with access to funds for this purpose are encouraged to allow complete subsidy, regardless of length of article, to avoid contributing toward a backlog of papers awaiting publication.

NOTE: Manuscripts should be *neatly* typed, with generous margins, double-spaced (including particularly bibliographies, figure legends, and other technical matter), and submitted in duplicate to simplify review. Use 8½ × 11 inch paper, and avoid "erasable" kinds! Please save the time of authors, editor, and printer by conscientiously following the style of current issues in regard to headings, identifications of authors beneath the title, citation of literature, abbreviations, and other matters of form. In "Literature Cited," only the name of the first author is inverted when there are two or more authors; if it is not desired to repeat an author's name, a long *dash* (not an underline) replaces it; if complete names of authors as in original publication are not used, then *all* names (except surname) should be consistently reduced to initials; and complete pagination should be indicated for all titles. An "&" rather than "and" is used in Literature Cited and all references in parentheses; italics are *not* used in Literature Cited; in titles of journal articles, only the first word and proper nouns (including names of genera and higher categories) are capitalized; all principal words are capitalized in names of journals and titles of books, bulletins, theses, and other non-journal articles. Check "Michigan Plants in Print" or current issues for examples of abbreviations and style. Illustrations and maps are encouraged so long as they can be reduced to page size (4½ × 7 inches); all are numbered consecutively as "Figures."

Page proof is sent to authors (at least in North America) and must be checked for errors and returned promptly; major revisions cannot be made at this time. Reprints (with extraneous matter removed) can be supplied at standard prices established by the printer (rate schedule available from the editor). An order form is supplied with proof.

—The Editorial Board

Program Notes

May 13: State Meeting, Michigan Botanical Club, at Michigan State University, East Lansing. In the morning, a Board meeting and tours of the Beal-Garfield Botanic Garden, which will be celebrating its 100th Anniversary. Founded in 1873 by W. J. Beal, this is the oldest continuously operated botanic garden in the U.S. and displays more than 5000 taxa. In the afternoon, a program and membership meeting.

May 26-28: Annual Spring Campout, Michigan Botanical Club, at Northern Michigan University, Marquette. Arrangements are being made for meals and lodging in campus dormitories, with field trips scheduled to various sites. All members will receive full details shortly.

Editorial Notes

The attention of prospective authors is called to the slightly revised "Information for Authors" on p. 142 of this issue.

Authors of recent articles who wish to have original manuscripts, photographs, and/or art work returned should inform the editor soon, as another "house-cleaning" of his files is imminent.

Photographers are urged to submit candidates for cover pictures. Sharp prints, horizontally oriented, should be of outstanding quality, ideally with that indefinable dramatic flair which proclaims them to be of cover quality! A modest payment of $5.00 is made for each photo used.

The January number (Vol. 12, No. 1) was mailed January 26, 1973.

A NOTE ON ADDRESSES

Only *editorial correspondence* should be sent to the editor, at the University of Michigan Herbarium.

All *subscribers* who are not members of the Michigan Botanical Club should send address changes promptly to the business and circulation manager. The *only* address records she keeps are those for non-members.

All *members* of the Michigan Botanical Club should keep the proper chapter officers (or, for State members, the Treasurer) informed of address changes. Members should *not* send address changes to the editorial or business offices of *The Michigan Botanist,* for we only have to forward them back to the chapters, which have the sole responsibility for maintaining members' address records.

All orders for back issues and for non-member subscriptions and renewals should be sent to the business and circulation manager, *not* to the University of Michigan Herbarium. (Institutions receiving the journal on *exchange* from the University of Michigan Library should, of course, deal only with the Library.)

Failure to send communications to the proper address (see inside front cover) will only delay attention to them.

UNIVERSITY OF MICHIGAN BIOLOGICAL STATION

The 65th annual summer session of the University of Michigan Biological Station on Douglas Lake will run June 25-August 18, 1973, for 8-week courses (10-week course starts June 11). In addition to classes in zoology, systems ecology, and stressed ecosystems, there will be two courses in geology this year and the following in botany: Taxonomy of Flowering Plants (Voss, 10 weeks), Freshwater Algae (Stoermer), Ecology of Phytoplankton (Stoermer), Lower Fungi (Shaffer), Higher Fungi (Shaffer), Boreal Flora (Voss), Aquatic Flowering Plants (Haynes), Plant Ecology and Ecosystem Analysis (Richardson). Research facilities are available throughout the year. For the current Announcement and application forms, address Dr. David M. Gates, Director, U. of M. Biological Station, Ann Arbor, Michigan 48104.

CONTENTS

E. Lucy Braun (1889-1971), Outstanding Botanist and Conservationist: A Biographical Sketch, with Bibliography
Ronald L. Stuckey 83

Chromosome Studies of Some Mosses of the Douglas Lake Region. III
Jerry A. Snider 107

Leucobryum albidum New to Michigan
Howard Crum 117

Studies on Michigan Chrysophyceae. II
Daniel E. Wujek & Ralph Hamilton 118

Chromosome Numbers in *Clintonia borealis* (Liliaceae)
Frederick Utech & Leonard B. Thien 122

Review—The North Woods 128

Comparative Micromorphology of Spore and Elater Ornamentation in *Blasia pusilla*
Jane Taylor, Gordon J. LeVee, Peggie J. Hollingsworth, and Wilbur C. Bigelow 129

Publications of Interest 133

Reviews—Wildflowers and Weeds
Desmidiales Part I
Vaucheriaceae
The North American Species of Psathyrella
Wild Plants in Flower: The Prairie
Forests of Lilliput 135

Michigan Plants in Print 139

XII International Botanical Congress 141

Information for Authors 142

Program Notes 143

Editorial Notes 143

(On the cover: A sign of spring—
Bloodroot, Sanguinaria canadensis,
photographed in April near Midland, Michigan, by Harold F. Tweedie.)

33
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Vol. 12, No. 3

THE MICHIGAN BOTANIST

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THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager.

Address changes from Botanical Club members should be sent to appropriate chapter officers. Address changes for *non-member subscriptions only* should be sent to the business and circulation manager. *No* address changes should be sent to the editor.

Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow current style and the suggestions in "Information for Authors" (Vol. 12, p. 142; copies available from the editor).

Editorial Board

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THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter) may send $3.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

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TWO MISUNDERSTOOD SPECIES OF *GYROMITRA* (FALSE MOREL) IN NORTH AMERICA

Kent H. McKnight
Plant Protection Institute, Agricultural Research Center,
U.S. Department of Agriculture, Beltsville, Maryland

INTRODUCTION

Gyromitra caroliniana (Bosc ex Fr.) Fr. and *Gyromitra brunnea* Underwood are two widely misunderstood species among the larger discomycetes of the North American flora. The Brown False Morel (*G. brunnea*) is found in Michigan in early spring, but the occurrence of the Carolina False Morel (*G. caroliniana*) this far north has not been verified.

The first published description and illustration of *G. caroliniana* by Bosc (1811) (as *Morchella caroliniana*) are inadequate to distinguish it without doubt among several species in North America and subsequent studies have not completely resolved the confusion. By contrast, the collections from which Underwood (1894) described *Gyromitra brunnea* are maintained in good condition at the New York Botanical Garden (NY) and the description was detailed and accurate. These, together with an excellent photograph published by Lloyd (n.d.) and later by Seaver (1928, 1942), leave less doubt as to what this species is, although the range of its morphological variation is poorly known. Herbarium specimens of both species are frequently misidentified. In spite of much nomenclatural confusion, discussed later, the following descriptions show that the two species are clearly distinct as recognized by Underwood and Seaver, as well as by contemporary American mycologists.

DATA[1]

GYROMITRA BRUNNEA Underw. Proc. Ind. Acad. Sci. 1893: 33, 34. 1894.
=*Elvela underwoodii* Seaver. North Amer. Cup Fungi 254. 1928.
Fig. 1; pl. 1.

Ascocarp stipitate; receptacles typically two to several per ascocarp, 5-12 cm across in the widest direction, everted, roughly saddle-shaped but often lobed and folded, not fused at margins, margin thick, rounded, sterile, not fused with stipe, excipulum rough on surface and furfuraceous at first, particularly toward the margin, near light grayish yellowish brown (Centroid 79: 9.7YR 6.4/2.5) to yellowish gray (10YR 7/2) as it dries, hymenium wrinkled, strong brown (5YR 4/6) to moderate reddish brown (2.5YR 3/5), often with more reddish overtones, odor and taste not distinctive. Stipe thick,

[1]In the species descriptions, color names preceding specific values in parentheses follow the terminology of Kelly and Judd (1955).

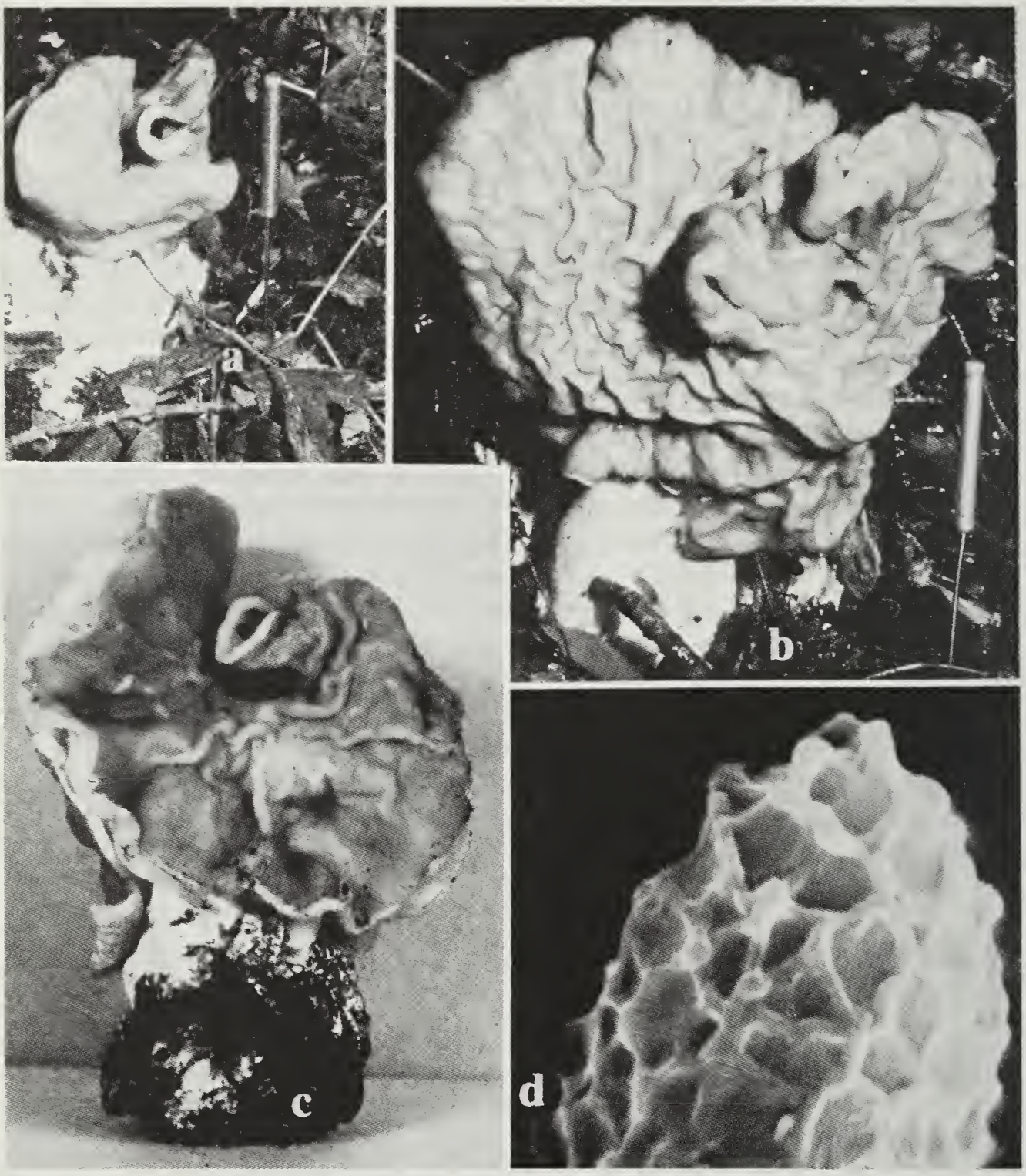

Fig. 1. *Gyromitra brunnea* (Brown False Morel). a,b, habit photographs of the same ascocarp, about 3/4 natural size. a, April 30, 1972, b, May 17, 1972. Specimens and photographs donated by R. T. Pennoyer. c, Nearly mature ascocarp (Miller 8273), about 3/4 natural size. Specimen and photograph donated by O. K. Miller. d, SEM photograph of part of one mature ascospore, ca. 5200×.

expanded at the base, sometimes with branches visible below the lowest receptacle lobes, coarsely and irregularly ribbed longitudinally, surface white, matted fibrillose, interior composed of anastomosing channels, hollow or stuffed, 2.5-6.0 (7) × 6-9 cm.

In section, hymenium 360-550 μ thick, subhymenium poorly differentiated, medullary excipulum and ectal excipulum similar but distinguishable, both composed of loose textura intricata made up of slender, interwoven cells, those of medullary excipulum tending to periclinal orientation while those of the ectal excipulum are indistinctly anticlinal. Paraphyses and marginal filaments of ectal excipulum next to hymenium dark dull brown with granular content in water, yellowish brown with granular content in Melzer's solution, in KOH light yellowish brown but fading rapidly as granules dissolve and pigment diffuses out, 3-5 septate, 5-9 μ in diameter; asci cylindric, contorted in the lower part and abruptly tapered at the base, apex broadly rounded, 18-25 × 400-525 μ; asci J-; ascus protoplasm bright yellowish orange in Melzer's. Spores elliptic, hyaline, slightly flattened, thick-walled, 1- to 3-guttulate, coarsely reticulate with slender spicules arising from the intersections; 24-30 × 11.5-14.0 μ, ornamentation 0.5-1.4 μ high.

HABIT, HABITAT, AND DISTRIBUTION: Solitary to gregarious, on soil or well-rotted wood in hardwood forests from Oklahoma to Iowa eastward and northward to the Great Lakes.

LECTOTYPE: Underwood (1), V.1892. Greencastle, Putnam County, Indiana (NY).

COLLECTIONS STUDIED: DISTRICT OF COLUMBIA: Braendle-Lloyd 14131 (BPI). INDIANA: Underwood (1), (2), (3), (4), (5): TYPE; Banker 1263, 1344, 3832 (NY); Stifler 9.V.1936 (BPI); Whetzel VI.1907; Williams 4.V.1908 (CUP). IOWA: Anonymous 6.V.1960 (BPI). MARYLAND: McKnight 10730, 10739, 11730, 12090 (BPI). MICHIGAN: Cain 1.V.1949; Homola 1869 (MICH); Honey H553 (NY); Kauffman 28.IV.1910; Osterhout 31. V.1958; A. H. Smith 58309; Tulecke & Voss (Smith 41235) (MICH); Wehmeyer 7.V.1953 (DAOM). MISSOURI: Burt 1.V.1920 (FH); Glatfelter-CUP 5-10 (CUP); Miller 28.III.1938; Oster 1.IV.1921 (BPI); Routien 711 (TENN). OHIO: Cibula 22, 34 (MASS); Hard 1(?).V.1909 (CUP); Lea 58 (K); Lloyd 057, V.1897, V.1902, 15153, 15155, 15164; Moore 9.V.1909; Probst 20.IV.1903, 29.IV.1905; Smith-Lloyd 15154, 15175; Walters 5.V.1949; Wolfgang 11.V.1917 (BPI). TENNESSEE: Hesler 24.IV.1940 (TENN). VIRGINIA: Baldwin 4.IV.1943 (BPI). WEST VIRGINIA: McKnight 11735 (BFDL, BPI).

OBSERVATIONS: A distinctive field character is the more or less saddle-shaped receptacle or multiple receptacles that are characteristically wrinkled, are lobed, and often overlap. Folds of the lobes arch upward. They show little or no tendency to fuse at the margins to form a compound receptacle as in *G. caroliniana* (compare Fig. 1 & Pl. 1 with Fig. 3). Stipes are branched but superficially may appear unbranched. The lower part forms a massive stalk and branches may originate low enough to be seen below the lobes of the receptacles (Pl. 1). Spore ornamentation consists of a coarse reticulum having thick, widely spaced ridges and a tendency, particularly towards the ends of the spores, for the formation of elongated knobs, spines, or plates at the intersections of the reticulum. The coarse reticulum is reminiscent of that on spores of *Discina leucoxantha* but the ridges are higher and spaced much wider and the apical appendages are different. Although

there is not sufficient information available to give an accurate picture of its distribution in North America, the collections studied for this report indicate a possible range from the Missouri Valley eastward and north of the 35th parallel.

GYROMITRA CAROLINIANA (Bosc ex Fr.) Fr. Öfvers. Kongl. Vet.-Akad. Förhandl. 2: 173-174. 1871. Figs. 2, 3, & 4.

≡ *Morchella caroliniana* Bosc ex Fr. Systema Mycologicum 2: 12. 1823. (based on *Morchella caroliniana* Bosc. Ges. Naturf. Freunde Berlin Mag. 5: 86, t. 5. 1811).

= *Helvella costata* Schw. Syn. Fung. Carolin. Super. 1822.

≡ *Gyromitra costata* (Schw.) Cooke. Mycographia 194. 1878.

≡ *Helvella caroliniana* (Bosc ex Fr.) Seaver. North Amer. Cup-fungi 253. 1928. (pro parte)

≡ *Mitrophora caroliniana* (Bosc ex Fr.) Lev. Ann. Sci. Nat. III. 5: 250. 1846.

≡ *Neogyromitra caroliniana* (Bosc ex Fr.) Imai. Bot. Mag. Tokyo 46: 174. 1932. (pro parte)

non *Neogyromitra caroliniana* (Bosc ex Fr.) Imai emend. Maas Geesteranus. Koninkl. Nederl. Akad. Wetensch. Amsterdam Proc. Ser. C 68: 133. 1965.

≡ *Fastigiella caroliniana* (Bosc ex Fr.) Benedix. Kulturpflanze 17: 277. 1969.

≡ *Discina caroliniana* (Bosc ex Fr.) Eckblad. Nytt Mag. Bot. 15: 100. 1968.

Ascocarp stipitate, of irregular shape but roughly globose to ellipsoid; receptacle compound, everted, 5-13 cm across, costate to strongly convoluted with margin appressed against the stipe, about 1.5 mm thick, hymenium moderate reddish brown (2.5YR 3/4) to moderate brown (5YR 4/4) or strong brown (2.5YR 3/6 to 5YR 3/6), externally white or nearly so, odor and taste not distinctive. Stipe thick and fleshy, irregular in shape, branched above but branches not visible below lobes of receptacle, expanded at the base, 2.5-7.5 × 3-15 cm, strongly ribbed with rounded, longitudinal ribs that branch and diverge above, surface white or nearly so, interior multichanneled.

In section, hymenium 475-550 μ thick, subhymenium of compact textura intricata about 150 μ thick, medullary excipulum of loose textura intricata 550-600 μ thick, composed of cells 8-11 μ in diameter, ectal excipulum similar but consisting of loose textura intricata that becomes more compact toward the exterior surface of the apothecium, 400-475 μ thick, hyphae 8-12 μ in diameter, indistinctly anticlinally oriented but more so toward the surface and there forming a loose palisade. Paraphyses cylindric, unbranched but sometimes contorted at apex, dull ochraceous brown in water mount (fresh), dull ochraceous brown in Melzer's solution, quickly bright rusty orange in KOH. Spores hyaline, elliptic, tapering slightly toward the broadly rounded ends, slightly flattened, thick-walled, 1- to 3-guttulate; surface reticulate with thick, very wide-spaced ridges forming a mostly closed

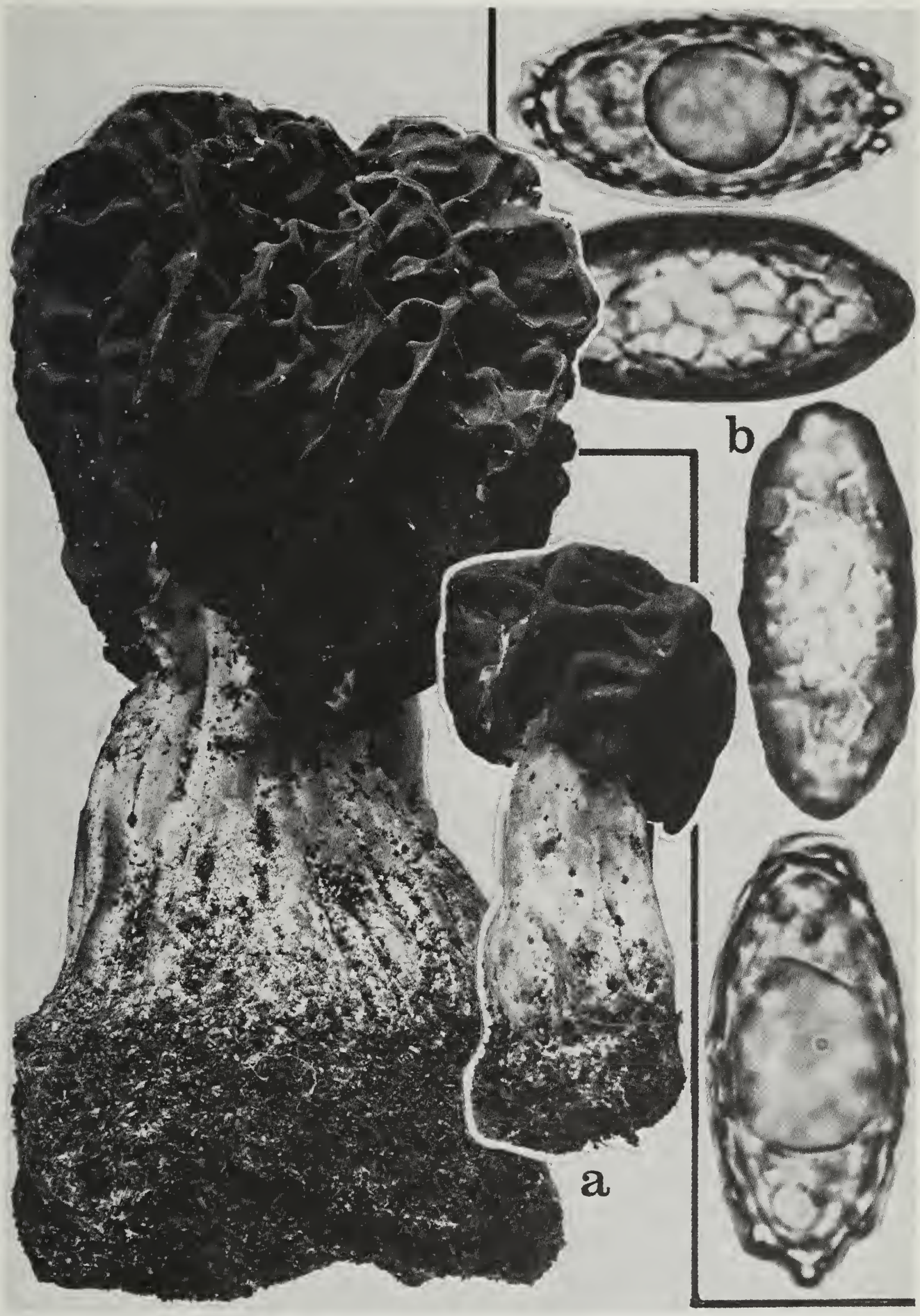

Fig. 2. *Gyromitra caroliniana* (Carolina False Morel). a, neotype, about 3/4 natural size. b, ascospores, ×1000.

Fig. 3. *Gyromitra caroliniana* (Carolina False Morel) showing compound costate receptacle and stipe branching at the apex, actual size.

reticulum drawn up into coarse spines, warts, or plates particularly toward the ends of the spores and numerous spicules apart from the reticulum, 22-35 x 11.5-16.5 μ, ornamentation 0.5-2.0 μ high.

HABIT, HABITAT, AND DISTRIBUTION: Solitary to gregarious, in hardwood forest, Oklahoma to South Carolina and north almost to the Great Lakes.

NEOTYPE: Bland 24.IV.1942, Lorton, Virginia (BPI).

COLLECTIONS STUDIED: ARKANSAS: Trelease 5.IV.1899 (BPI). ILLINOIS: Roos 9.V.1924; Schenk IV.1901 (BPI). INDIANA: Banker 1318 (NY); Thorne 3.V.1937 (FH); Ziegler 26.IV.1930 (BPI). KANSAS: Bruner, 1931 (NY). MARYLAND: Briscoe 23.IV.1937; McKnight 12900 (BPI). MISSOURI: Burk 22.IV.1917 (BPI); Bush 30.IV.1917 (BPI and FH); Durand 2986 (CUP); Glatfelter 835 (BPI); Grant et al. 5.IV.1931 (TRTC); Grant et al. 6.IV.1931 (BPI and FH); Heinemann 3.IV.1961 (MICH); Reed 13.IV.1911 (CUP); Spaulding 7.IV.1906 (BPI). OHIO: Foerst-Lloyd 43927; Stover-White 1679 (FH); OKLAHOMA: McKnight 11216; Stratton 4.IV.1926 (BPI). SOUTH CAROLINA: House 10.IV.1906 (BPI). TENNESSEE: Hesler 11973, 11974; Rankin 7.IV.1954 (TENN). VIRGINIA: Bland 24.IV.1942 (BPI).

OBSERVATIONS: The costate caps composed of several fused receptacles on a massive, multichannelled stalk are the distinctive field characters of *Gyromitra caroliniana.* The stalk is expanded at the base and because it is branched only in the upper extremities, one may easily get the impression that it is unbranched. There is a network of branches always hidden by the lobes of the receptacle. The outlines of the separate receptacles comprising the compound head may or may not be evident as they fuse partly or completely on their margins, often giving the whole ascocarp a distinctly morchelloid appearance. Although its distribution overlaps that of *G. brunnea* in much of the area, *G. caroliniana* appears to be a more southerly species. Collections have been studied from as far south as South Carolina. Apparently *G. caroliniana* is collected much less than *G. brunnea.*

A collection made at Lorton, Virginia, April 24, 1942, by Oscar E. Bland is designated as neotype. The five specimens represent the species well as it has been traditionally known in this country. Mature spores are present on them and a range of sizes characteristic of the species is represented. An excellent photograph of two of the fresh specimens is reproduced here in Fig. 2. Specimens and the original photograph are on file at BPI.

MORPHOLOGY

Recent studies emphasize the importance of microscopic characters, particularly details of spore morphology, in distinguishing closely related species of *Gyromitra.* In the two species considered here, however, differences of gross morphology are the most useful characters in separating the species and the very subtle spore differences are secondary characters confirming the distinction. Most significant is the characteristic fusion along the margins of the lobes of the receptacle in *G. caroliniana* and their lack of fusion in *G. brunnea.* In occasional specimens of *G. caroliniana* reported here these "suture" lines are not evident and in some the compound receptacle looks very much like that of *G. gigas* (Krombh.) Quél. or *G. fastigiata* (Krombh.) Rehm. When *G. brunnea* and *G. caroliniana* are seen together, the much more costate, often morchelloid appearance of the receptacle distinguishes *G. caroliniana,* whereas *G. brunnea* characteristically has arching lobes giving at least a suggestion of a saddle-shaped, helvelloid form. There is a wide range of morphological variation in both species, however, and much additional field study is needed for a final appraisal of the possible significance of the variant forms. Developmental studies of very young ascocarps of both species might prove most valuable. Branching of the stipe below the lobes of the receptacle immediately distinguishes those specimens of *G. brunnea* on which this occurs (Pl. 1). This condition is never seen in *G. caroliniana* (Figs. 2 & 3) and not always in *G. brunnea* (Fig. 1). Stipes of both branch repeatedly in the upper part where the branches are hidden by lobes of the receptacles. Clearly these two species have compound ascocarps, a character not definitely recognized in the *G. infula-G. esculenta* complex; yet in *G. gigas* and *G. fastigiata* this is developed further than in *G. brunnea* or *G. caroliniana.* This may have

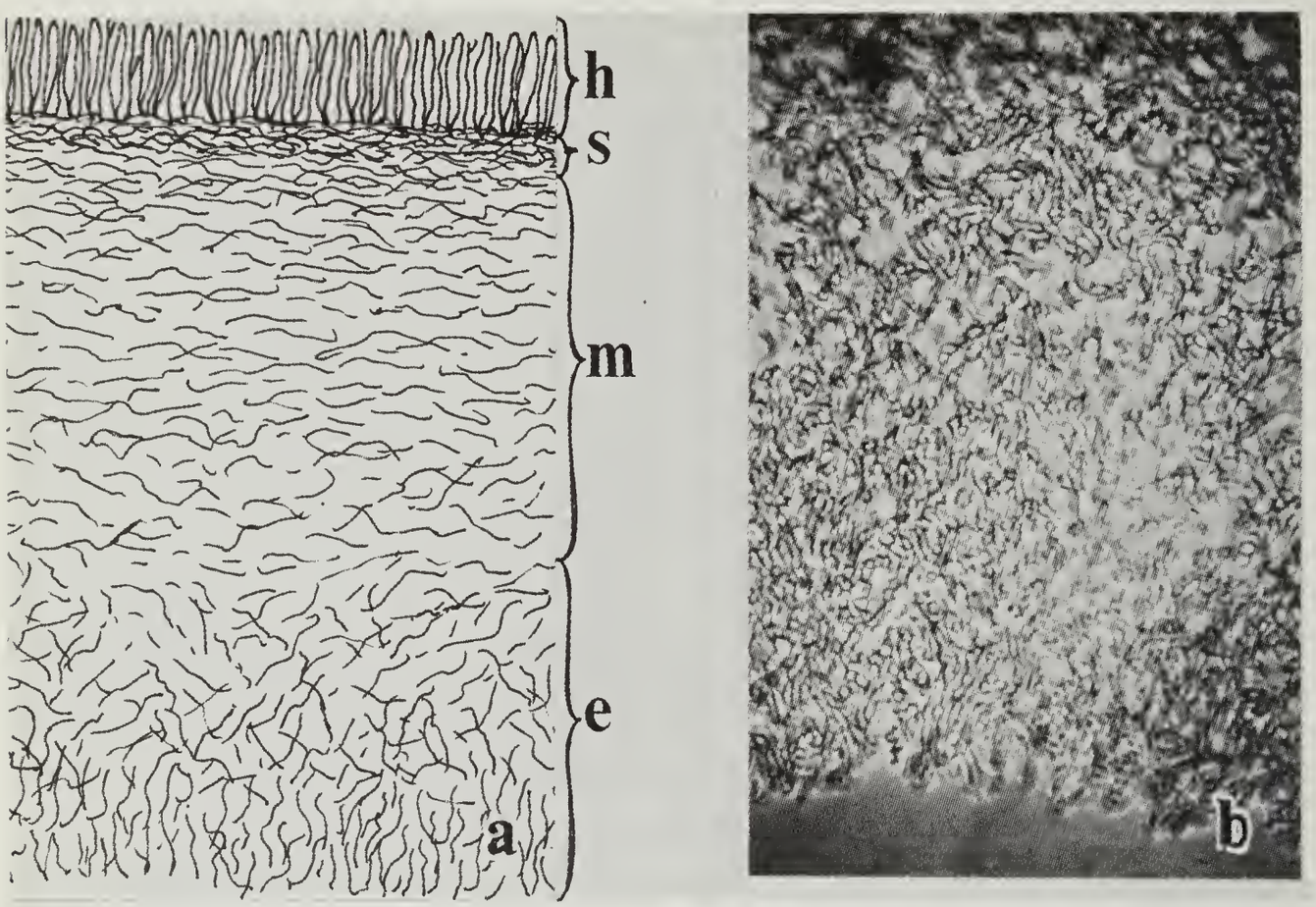

Fig. 4. *Gyromitra caroliniana* receptacle in section. a, diagram of receptacle in longi-section; (h) hymenium, (s) subhymenium, (m) medullary excipulum, (e) ectal excipulum. b, photomicrograph of ectal excipulum, ×180.

considerable significance in the interpretation of possible relationships within the Helvellaceae.

These two species can be interpreted as exhibiting intermediate evolutionary steps in development of the compound gyromitroid ascocarp from a simple one. Thus in gross morphology their forms are intermediate between those of two clearly distinct species complexes. On the one side there is the type species, *Gyromitra esculenta,* and related species which have a single receptacle on a hollow or stuffed, typically one-channelled stipe.[2] On the other side there are *Gyromitra fastigiata* and *G. gigas,* which have massive, internally multichannelled stipes and wrinkled to highly convolute receptacles.

Species of *Discina*, which may have evolved from this form by reduction, have stipes lacking or very short and solid, bearing smooth to convolute receptacles. Whether they represent one genus (Harmaja, 1969a) or several (Benedix, 1969) or whether this is a single evolutionary series or more

[2]All specimens of *G. esculenta* that I have examined for this character to date have hollow, one-channelled stipes. However, in a recent personal communication, Dr. R. A. Maas Geesteranus describes a collection of this species at Leiden (L) consisting of old ascocarps all with multichannelled stipes. In his description of *M. caroliniana* Bosc noted this difference in *G. esculenta* and *G. caroliniana.* Fries (1823) quoted it and, I believe, suggested its importance later in his subgenus *Lacunaria* (1871).

than one can be resolved best after assimilation of additional information not only from more intensive field study but also from cytology, genetics, and biochemistry.

Structure of the outer tissues of the recptacle of *Gyromitra* and *Discina* is rarely reported accurately, possibly because of too few critical studies on fresh material. As indicated in Fig. 4a the difference between ectal and medullary layers is more one of hyphal orientation rather than cell shape. Both consist of textura intricata. The medullary excipulum has predominantly periclinal hyphal orientation (Fig. 4a). Adjacent to it the upper layer of the two-layered ectal excipulum has more anticlinal hyphal orientation (Figs. 4a & b) becoming progressively more anticlinal toward the more compact, distinctly anticlinal lower layer. The outer layer of the ectal excipulum is so poorly revived in dried specimens that it is apparently very rarely seen. Without it, the difference between the other two excipular layers is so subtle as to be consistently ignored. Only quite recently have I learned that it shows up well on free-hand sections mounted in water. All other mounting fluids tried, including weak KOH, caused distortion of the tissues.

In the genus *Gyromitra* subtle differences in spore shape, size, or ornamentation have been shown to be the most reliable characters for distinguishing certain species from their closest relatives such as *Gyromitra infula* (Schaeff. ex Fr.) Quél. and *G. ambigua* (Karst.) Harmaja (Harmaja, 1969b); *G. fastigiata* (Krombh.) Rehm and *G. gigas* (Krombh.) Quél. (McKnight, 1971); *G. tasmanica* Cooke and *G. antarctica* Rehm (Gamundi, 1971). Other reports emphasize spore characters in distinguishing species of *Gyromitra* that are not so closely related (Maas Geesteranus, 1965; Raitviir, 1965, 1970; Benedix, 1969; Harmaja, 1969a; Svrček & Moravec, 1972). However, the situation is different with *Gyromitra brunnea* and *G. caroliniana* wherein the species are identified most easily on characters of gross morphology.

Differences in spores of the two species reported here concern the depth of the reticulum, which is greater in *G. caroliniana* than in *G. brunnea*, and the distribution of the spines. In *G. brunnea* the spicules that arise mostly at intersections of the reticulum are confined largely to the ends of the spores. In *G. caroliniana,* on the other hand, there are more that arise apart from the reticulum and they are found more frequently along the sides of the spores, away from the ends. Differences in spore dimensions appear to be quite insignificant but the spores of *G. caroliniana* are, on the average, slightly broader than those of *G. brunnea.* In establishing limits both of genera and species as well as in postulating relationships within the family, one should keep in mind the warning of LeGal with reference to spore surface features: "Quand on a voulu attribuer aux *apicules* une valeur taxinominque particulière, on n'a abouti, jusqu'ici, qu'à des reclassements artificiels et non valables." (LeGal, 1964, p. 468). Nonetheless, these minute, subtle differences in spore ornamentation and shape are consistent within reasonable limits and appear to correlate with differences in gross morphology. Contrary to the situation in other species complexes, differences in ornamentation and

shape of *G. brunnea* and *G. caroliniana* spores have little use in species identification but they are valuable in determining species limits.

Careful study of *Gyromitra brunnea* and *G. caroliniana* shows that characters of gross morphology that have recently fallen somewhat into disfavor are still important in taxonomy of the Helvellaceae when used correctly. In these two species they can be correlated with the following characters: (1) thickness of the receptacle; (2) details of hyphal organization and structure of the excipulum; (3) color; (4) spore characteristics. In regard to each of these characters, species of the *G. caroliniana* complex differ in small degree from those of each of the two adjacent species complexes listed above. Thus, there would be some support for generic splitting. On the other hand, *G. caroliniana* and *G. brunnea* are intermediate in a continuum of variations in characters of gross morphology and possibly also for excipulum structure and other characters.

Modern taxonomic research has often shown that there is much to be learned about previously described species when interpreted with as many kinds of data as possible. Through such endeavors species discarded by earlier taxonomists have sometimes been restored to favor. In *Gyromitra* this broad-range study approach utilizing new as well as old study methods should be helpful in improving classification of species in genera or in infrageneric taxa.

TAXONOMY AND NOMENCLATURE

Bosc (1811) described *G. caroliniana* in the genus *Morchella,* and illustrated a large fungus with a massive, multichannelled stipe and a lobed and folded recptacle. Nees (1816) recognized that the more or less solid but internally channelled flesh of the cap (actually the upper stipe) distinguished Bosc's species from *Morchella* and tentatively placed in it *Helvella* while expressing doubts that this was the correct genus. Fries validated the species name as he included it in *Morchella* (1823), but later called it *Gyromitra caroliniana* (1871).

Gyromitra costata (Schw.) Cke. was inadequately described by Schweinitz as *Helvella costata* and has been confused from time to time with both *G. brunnea* and *G. caroliniana.* There is no material of this in the Schweinitz herbarium at Philadelphia or the Michener Collection at BPI which contains many Schweinitz types. Fries (1823) placed *H. costata* in his Sect. *Pezizoideae* along with *H. atra* Holmskj. ex Fr., *H. pezizoides* Afz. ex Fr., and *H. elastica* Bull. ex St. Amans; and Saccardo placed it in Sect. II, *Venosae* Cke. Cooke (1878) illustrated the species from a dried specimen in the Berkeley herbarium, showing a fungus with much more the appearance of *G. brunnea* than *G. caroliniana.* He described the spores, which are narrower and much more pointed than those of *G. brunnea* or *caroliniana.* His drawings were apparently made from Curtis 2247 in the Berkeley Herbarium at Kew. Maas Geesteranus has examined this collection and finds it to be a form of *G. brunnea* Underw. (pers. comm.). He thinks it could not be the type specimen of *H. costata,* which Schweinitz described as having a non-adnate, revolute

Plate I. *Gyromitra brunnea* (Brown False Morel) showing branched stipe, about 3/4 natural size. From a watercolor painting by Vera B. McKnight.

margin, sometimes showing its ribbed underside. Maas Geesteranus noted also that the stipe of *H. costata* is said to be lacunose whereas that of Curtis 2247 is sulcate. Massee may have studied the same specimen because there is a drawing (but no accompanying specimen) in the Massee Herbarium at the New York Botanical Garden marked "type" and showing uniguttulate, nodulose spores that look superficially like those of *G. brunnea* but that lack the characteristic, coarse reticulum. A note on the sheet says, "spores smooth when immature, then coarsely nodulose. The warts often largest at the two ends of the spore." The original description of *G. costata* gives no microscopic details. The lacunose stipe and free, subrevolute cap margin suggest a fungus in stature more like *Gyromitra sphaerospora* (Pk.) Sacc. or *G. californica* (Phill.) Raitv. The latter can be eliminated since it grows only in western North America. It is still possible but very unlikely that this name should apply to a fungus close to, yet distinct from, *Gyromitra brunnea* or *G. caroliniana.* Not enough collections from southeastern United States have been studied to be certain that there is not a fungus there with the general form of *G. brunnea* and with spores as illustrated by Cooke or Massee. At least for the time being I prefer to retain the name *G. brunnea* for the common species reported here as it has been understood in North America since Underwood first described the species, and for which there is excellent type material. *Gyromitra costata* remains as a mystery for the time being.

Gyromitra labyrinthica Fr. is obviously a very similar fungus and may be a synonym of either *G. costata* or *G. caroliniana,* or it may be the same as *G. brunnea.* This name has not been used by European mycologists who have mistakenly assigned similar material to *Gyromitra caroliniana.* Fries (1871) indicated a close relationship between *G. labyrinthica* and *G. caroliniana* and erected a separate subgenus for them. Again there is no extant type, but on the basis of an unpublished drawing, Nannfeldt (1932) regarded *G. labyrinthica* as a synonym of *G. gigas* [=*G. fastigiata* (Krombh.) Rehm ss. McKnight (1971)]. I see no basis for a different conclusion.

Nothing in Bosc's description or illustration of *Morchella caroliniana* distinguishes his species from the more gyrose-costate forms of two species described later by Krombholz: *Helvella gigas* Krombh. and *H. fastigiata* Krombh. (*non sensu* Benedix, *non* Svrček & Moravec). In North America *Gyromitra gigas* has not been found east of Colorado, but *G. fastigiata* has been found in North Carolina and could be the same as *G. caroliniana.* Such an interpretation would necessitate adding still another name to the nomenclatural jungle.

Although Krombholz (1834) may have described it under the name *Helvella inflata* Cum., *Gyromitra caroliniana* was of little concern to European mycologists until Seaver (1928) included it in the genus "*Elvella*" L. (=*Helvella*) and referred two European species to it as synonyms. He did not confuse *G. brunnea* (=*Helvella underwoodii* Seaver) with *G. caroliniana* as some have supposed, although these two American species seem to be widely misunderstood in Europe. Seaver distinguished them correctly on gross morphology. However, what is confusing in his reports on these fungi is the

Fig. 5. Ascospores of three species of *Gyromitra*, all approximately × 1000. a, *Gyromitra fastigiata.* b, *Gyromitra gigas.* c, *Gyromitra caroliniana.*

very broad species concept with regard to *Gyromitra caroliniana.* Here, as also in his general systematic scheme for the discomycetes, he attributed too much importance to morphological form and too little to microanatomy and to microchemical reactions. In *G. caroliniana* he lumped together all of the gyromitroid forms with much wrinkled to convolute or costate hymenium and massive, multichanneled stipe except *G. brunnea.* This brought together under one species epithet the following three species that are easily distinguished on microscopic characters: *G. caroliniana, G. gigas,* and *G. fastigiata.* This misjudgment was indeed the source of much confusion in the interpretation of several species of *Gyromitra* in the three decades following the appearance of his emended book (Seaver, 1942). But it does not follow that *G. brunnea* and *G. caroliniana* were confused by Seaver or that they have been confused consistently, as intimated by Raitviir (1970). On the contrary, many American mycologists have accurately understood *G. brunnea* with consistency. Some, like Seaver, included other species in their concept of *G. caroliniana* but some, who have studied both species, have followed consistently the concepts of the two species reported here.

In synonymy under *Helvella caroliniana,* Seaver listed the supposedly well-known *Helvella gigas* Krombh. as well as *Gyromitra curtipes* Fr. and *Helvella costata* Schw. Nannfeldt (1932) at first reluctantly followed Seaver's broad species concept for *H. caroliniana.* Then, because Seaver illustrated the species with coarsely reticulate-spiculate spores (1931), Nannfeldt pointed out

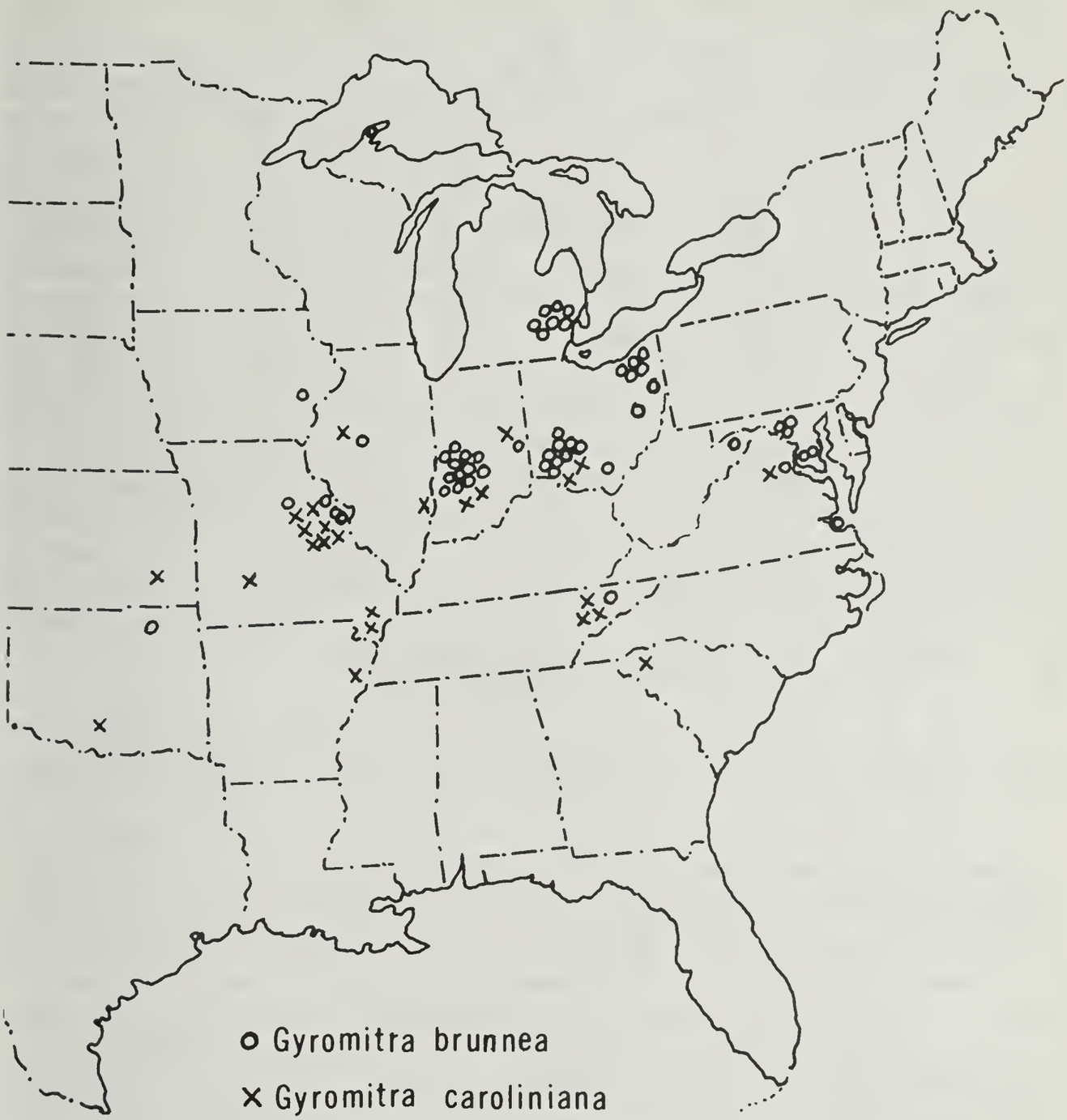

Fig. 6. Distribution of *Gyromitra brunnea* and *Gyromitra caroliniana* in North America based on collections studied for this report.

that it seemed to include fungi with two distinct spore types and that Seaver's fungus was definitely different from that known in Europe as *G. gigas.* Later (Lundell & Nannfeldt, 1946) he distributed exsiccati under the specific epithet, *gigas,* illustrating the concept of this species held by most European mycologists at that time. His exsiccati specimens have spores clearly different from those of *G. caroliniana.* Moreover, they are more like those in Krombholz's description of *Helvella fastigiata* Krombh. than in his *H. gigas.*

Imai (1932) cited *Morchella caroliniana* as the type species for his genus *Neogyromitra*, but when Seaver's illustration of the spores of this species (1931) appeared, Imai recognized it as different from the Japanese specimens that he had referred to the species and designated a new type for his genus:

Helvella gigas Krombh. (Imai, 1938). Possibly unaware of Imai's work, Herter (1950) described the same genus with *H. gigas* as the type and named it *Maublancomyces.* Later (1951) he specifically excluded *Gyromitra caroliniana* and *G. brunnea* from *Maublancomyces* on the basis of their ellipsoid spores contrasted with fusiform spores for his genus, *Maublancomyces.* In doing this, he ignored the fact that the original description by Krombholz (1834) emphasized that *G. gigas* has oval spores! Obviously Herter and Krombholz had different concepts of *G. gigas*. After intensive study of the species involved, Maas Geesteranus (1965) emended Imai's genus, *Neogyromitra*, and proposed as neotype *Morchella caroliniana* Bosc ex Fr. sensu Seaver, 1931.

Gyromitra fastigiata (Krombh.) Rehm is a European species that was quite generally ignored until Lohwag (1966) mentioned it in connection with the fusoid-spored fungus that most European mycologists were then calling *G. gigas.* In fact, accounts of *G. gigas* by European authors during the last century consistently described its spores as fusiform, whereas Krombholz's original description (1834, p. 29) says, "vollkommen oval." Lohwag reproduced Krombholz's original description and illustrations of the species but concluded that *H. fastigiata* Krombh. and *N. caroliniana* Imai emend. Maas Geesteranus were the same. Benedix (1968) followed this interpretation of species when he erected a new genus for what he considered to be *G. caroliniana.* From his published photographs he obviously has something closer to *G. brunnea* than to *G. caroliniana.* More recently, Svrček and Moravec (1972) have elaborated on this concept of *G. fastigiata,* claiming *G. brunnea* as a synonym. This concept is clearly contrary to Krombholz's descriptions of the species. As I have already pointed out (McKnight, 1971), of the three basic spore forms found on collections of these species in Europe as well as North America, that shown in Fig. 5a comes closest to Krombholz's description of the spores of *H. fastigiata*: "elliptisch-spindelformig." Of course the other two (Figs. 5b and 5c) could also be called broadly fusiform. But if Krombholz had used this term to describe the spores shown in Fig. 5b or 5c, would he, in the same publication, have described spores as shown in Fig. 5a as "vollkommen oval"? Although all three spore types are found in specimens in European herbaria, that shown in Fig. 5b appears to be rare. But there is a good specimen of it at Naturhistorisches Museum, Vienna [Melzer 30.IV.1967 (W)].

Based on his opinion that only "a slight difference in form" separates *Discina* and *Neogyromitra,* Eckblad (1968) merged the two genera under *Discina* (and listed *Maublancomyces* as a synonym) with the new combination *Discina caroliniana* (Bosc ex Fr.) Eckbl. Harmaja (1969a), on the other hand, insisted that their spore structure is too much alike to separate *Gyromitra* and *Discina* and pointed out correctly that if such a broad generic concept is adopted the name "*Gyromitra*" has priority.

Like so many other authors, Raitviir (1970) apparently failed to consider the possibility that there are at least two *Neogyromitra*-like species having coarsely reticulate-spiculate spores and contended that *Morchella caroliniana* Bosc ex Fr. is a *nomen dubium* and *Morchella caroliniana* Bosc ex Fr. sensu Seaver is a *nomen confusum.* He then erroneously concluded that

"There is no doubt that *Gyromitra brunnea* Underw. is identical with *Neogyromitra caroliniana* Bosc ex Fr. (*sensu* Seaver p.p. and Maas G.) Imai and a valid name for this species." From the above summary it is apparent that the name *Gyromitra caroliniana* has been the source of much confusion as Raitviir suggests. But contrary to his contention, one need not conclude that this species is the same as *Gyromitra brunnea* Underw. The fungus illustrated by Seaver (1931) as *G. caroliniana* is indeed that species and his photograph of the Bruner collections is an excellent representation of one form of the species. Raitviir's conclusion places too much emphasis on spore similarities and ignores the obvious differences in morphology that have traditionally separated the species. It should be noted that both of these are American species and it is possible that neither of them occurs in Europe where most of the confusion is. Neither the published illustrations of European collections nor dried specimens kindly loaned by R. A. Maas Geesteranus look enough like *G. caroliniana* as it is known in this country to be that species. Morphologically some of them look enough like *G. brunnea* that they could be *brunnea*, but subtle differences in their spores cast doubt on this interpretation.

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THE LICHEN FLORA ON *ULMUS AMERICANA* IN NORTHERN MICHIGAN

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The Dutch Elm disease came to the United States from Europe about 1930 and is now found in 18 northeastern and central states where native elm trees are found (Strong, Janes, & Morofsky, 1955). The first elms known to die from the disease in Michigan were found in Detroit (Wayne County) during the summer of 1950. In the last 20 years, the number of living elms has been drastically reduced by the disease, and the remaining elm populations are seriously threatened.

The rapid disappearance of *Ulmus americana* prompted this study which was made in Emmet County, northern Lower Michigan. It seemed desirable to study the lichen flora since this unique habitat is rapidly disappearing.

The data presented here are taken from two major habitats: at the roadside in a well drained situation, and inside an elm swamp. The majority of the roadside elms appeared healthy compared to individuals found in the swamp. The lichen flora also distinctly differed between these two habitats and rather than attempt to discover the specific reasons for the contrast, I

TABLE 1. Presence of lichen species on *Ulmus americana* from two communities. Trees 1-10 are roadside elms. Trees 11-20 are swamp elms.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Caloplaca cerina	X	X	X																	
Candelaria concolor	X	X	X	X	X	X	X	X	X	X										
C. fibrosa	X	X	X	X					X											
Lecanora glabrata			X	X																
L. varia															X	X		X	X	
Parmelia caperata									X	X	X	X								
P. rudecta									X	X	X	X								
P. sulcata	X	X				X	X				X	X								
Pertusaria amara												X		X						X
P. velata							X						X			X	X	X	X	
Physcia adscendens	X	X	X	X	X	X	X	X	X	X										
P. aipolia			X	X																
P. setosa			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
P. stellaris	X	X	X	X					X	X										
Physconia grisea	X		X		X	X	X		X	X	X	X	X	X	X	X			X	
Xanthoria fallax	X	X	X	X					X											
X. polycarpa	X	X		X																

decided to analyze the lichen flora of the two habitats as to degree of similarity.

Two samplings of ten trees were made in this study. The first was along a five-mile portion of Van Road, a moderately traveled east-west gravel road. Companion species observed with *Ulmus americana* were chiefly *Acer saccharum* and *Populus grandidentata.*

The second sampling was along a 100-meter section through a hardwood swamp on the south side of Lark's Lake near Van Road (Section 16, T37N, R5W). Many of the elms in the swamp had recently died, and many of the live individuals appeared unhealthy. However, at the time of study, the lichen flora did not differ significantly between the live and dead elms.

In both samples, the sampling distance was divided into five equal sections. The roadside sample was divided into one-mile sections and the swamp sample into 20-meter sections. In each section, two elm trees were randomly selected and their lichen flora at breast height noted. The selection of trees was accomplished by a set of random numbers taken from a 1-10 series. The random selections (3-2-8-5-1) represent the distance traveled into each section (tenths of a mile along the roadside sample and meters for the swamp sample). Beginning at the eastern edge of sections 15 and 22 (separated by Van Road), T37N, R4W, the automobile was driven westward 0.3 miles as determined by the odometer. At this point, the nearest two elms were located and their lichen floras recorded.

The next number in the random set was 2. At the eastern edge of sections 16 and 21 (one mile west of the starting point), the automobile was driven 0.2 miles westward. Again, the nearest two elms were selected. This procedure was repeated for the complete 5-mile sample, each time using the next section westward and the next number in the random set. The trees in the roadside sample were numbered 1-10. The presence of lichen species is indicated in Table 1.

The procedure was modified slightly for the swamp sample to the extent of doubling the value of each of the random numbers in the 3-2-8-5-1 set and substituting meters for tenths of a mile. Doubling of each number (6-4-16-10-2) provided a more uniform distribution of sampling distances within the 20-meter sections. Beginning with the first 20-meter section of the sample, six meters were measured off and the nearest two elms examined. This procedure was repeated in each of the 20-meter sections in the same manner described for the roadside sample. The trees in the swamp sample were numbered 11-20. The presence of lichen species is indicated in Table 1.

The data collected in this study were indexed as to degree of similarity using a method developed by Sørensen (1948). Sørensen's index establishes a quotient of similarity which may be calculated as:

$$\text{Quotient of Similarity (Q.S.)} = \frac{2c}{a + b}$$

in which (a) is the total number of species in the first sample, (b) the total number in the second, and (c) the number of species common to both samples.

TABLE 2. Sørensen's index showing quotient of similarity for lichen species on *Ulmus americana* from two communities. (1-10 are roadside elms, 11-20 are swamp elms).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00																			
2	0.94	1.00																		
3	0.74	0.67	1.00																	
4	0.67	0.70	0.85	1.00																
5	0.46	0.33	0.57	0.46	1.00															
6	0.57	0.46	0.53	0.43	0.89	1.00														
7	0.53	0.43	0.50	0.40	0.80	0.91	1.00													
8	0.33	0.36	0.46	0.50	0.86	0.75	0.67	1.00												
9	0.67	0.59	0.74	0.67	0.62	0.57	0.53	0.50	1.00											
10	0.50	0.40	0.59	0.50	0.73	0.67	0.62	0.60	0.88	1.00										
11	0.29	0.15	0.27	0.14	0.45	0.60	0.55	0.25	0.57	0.67	1.00									
12	0.27	0.14	0.25	0.13	0.40	0.55	0.50	0.22	0.53	0.62	0.91	1.00								
13	0.17	0.00	0.31	0.17	0.57	0.50	0.23	0.33	0.33	0.40	0.50	0.45	1.00							
14	0.17	0.00	0.31	0.17	0.57	0.50	0.23	0.33	0.33	0.46	0.50	0.67	0.67	1.00						
15	0.17	0.00	0.31	0.17	0.57	0.50	0.23	0.33	0.33	0.40	0.50	0.45	0.67	0.67	1.00					
16	0.15	0.00	0.29	0.15	0.50	0.45	0.60	0.29	0.31	0.36	0.45	0.40	0.86	0.57	0.86	1.00				
17	0.00	0.00	0.17	0.18	0.33	0.29	0.50	0.40	0.18	0.22	0.29	0.25	0.80	0.40	0.40	0.67	1.00			
18	0.00	0.00	0.15	0.17	0.29	0.25	0.23	0.33	0.17	0.20	0.25	0.22	0.67	0.33	0.67	0.86	0.80	1.00		
19	0.15	0.00	0.29	0.15	0.50	0.23	0.60	0.29	0.31	0.36	0.45	0.40	0.86	0.57	0.86	1.00	0.17	0.86	1.00	
20	0.00	0.00	0.17	0.18	0.33	0.29	0.25	0.40	0.18	0.22	0.29	0.50	0.40	0.80	0.40	0.33	0.50	0.40	0.33	1.00

The application of Sørensen's Q.S. gives a numerical value indicative of the degree of similarity based on presence and allows the lichen flora on each tree to be compared to that on every other tree in the two samples. Higher values indicate a high degree of similarity, while lower values indicate a low degree of similarity. The highest possible Q.S. value is 1.00, indicating that the presence of lichen species was identical on the two trees. The other extreme, when two trees have no lichen species in common, gives a Q.S. value of 0.00.

Table 2 gives a composite of Q.S. values for the two samples. Q.S. values for trees 1-10 (roadside elms) are found in the upper left portion of Table 2, while Q.S. values for trees 11-20 (swamp elms) are located in the lower right portion. The Q.S. values in the lower left portion of Table 2 represent the degree of similarity found when the trees of one community are compared to trees of the other community.

The degree of similarity within each community was relatively high (average Q.S. for roadside elms = 0.66; average Q.S. for swamp elms = 0.64). This was not unexpected. However, the relatively low values obtained when the trees of the two communities were compared to one another (average Q.S. = 0.26) showed a significant contrast.

One may attempt to speculate as to the reasons for the contrast of lichen flora exhibited by the two communities, but it should be noted that this study provides no technical data upon which to base conclusions of this type. The possibility of some of the roadside trees having been planted and not being native could account for a contrast in lichen flora. Physical conditions which may be responsible for such a contrast may be attributed to roadside effects such as exposure, insolation, minerals from road dust, gases and particulates from automobile exhausts, light intensity, bark hardness, bark pH, and the relative health of the trees. The elms, so characteristic of Michigan hardwood swamps, will soon be gone in this area, and many more data are desirable before the remaining ones die.

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FORTY YEARS OF SUCCESSION ON AN ABANDONED BUILDING SITE AT THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION[1]

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During the winter of 1929-1930, the University of Michigan Biological Station was moved from its location on the southeast shore of Douglas Lake to the adjacent site previously occupied by Camp Davis, an engineering camp, on the south shore of the lake. Of particular interest in this study is the bare area left available for colonization by plants when the Botany Laboratory was transported to the new site (Gates, 1946; Nelson, 1956). Before construction of the Botany Laboratory in 1924, the area had been occupied by two roads, one of which was more than fifty years old, and was so disturbed by horse and wagon traffic that plants had not been able to become established (Gates, 1946).

Fig. 1. Area in 1971 showing method of mapping. Arrows indicate the edges of the plot. The right arrow indicates the northeast edge of the plot, which is represented at the top of all maps. Photo taken July 1971 by Thomas Duncan.

[1]Presented at the 76th Annual Meeting of the Michigan Academy of Science, Arts, and Letters, Michigan State University, East Lansing, 24 March 1972.

In 1931, 1940, and 1950, Frank C. Gates made detailed maps of this area to illustrate the trends and patterns of revegetation (Gates, 1946, 1952), but until 1971, no one had resurveyed the area. Because such studies over a relatively long period of time are scarce and because the area had obviously changed, a new map was made during July and August of 1971.

The stakes used by Gates in 1930 to outline the perimeter of the area were relocated. The 38-square-meter plot was then divided into one-square-meter sections, each marked with strings and flags (Fig. 1). Each square-meter area was then mapped. The symbols used were not, in some cases, the same as those of Gates (1952). However, the original maps, in the ecology files of the University of Michigan Biological Station, were redrawn (Figs. 6-8) to correspond to the map made in 1971 (Fig. 9).

DEVELOPMENT OF THE VEGETATION ON THE ABANDONED BOTANY LABORATORY SITE

In 1930, 18 species invaded the plot (Fig. 6). By 1931, the year of the first mapping, only 14 were present. Many of these species, such as *Chrysanthemum leucanthemum, Verbascum thapsus, Agropyron repens,* and *Agrostis gigantea,* are weedy colonizers of open exposed areas. Individuals of all these species were scattered over the plot and few in number. Most of the plot remained open sand (Fig. 2). Aspen suckers, from one or more clones centered outside the area, were present. Eight species, *Chenopodium album, Malva neglecta, Polygonum convolvulus, P. persicaria, Rorippa islandica, Setaria viridis, Triticum aestivum,* and *Epilobium angustifolium,* were seen during the first or second year after removal of the building, but not at the time of mapping (Gates, 1952).

In 1934, *Ceratodon purpureus,* a moss known as an early colonizer of open sandy areas, first appeared. It apparently disappeared by 1935, but reappeared in 1936 and by 1940 covered 46 percent of the plot.

In 1940, 12 of the 14 species mapped in 1931 were still present (Table 1; Fig. 7). Three species, *Arabis lyrata, Rhus Xborealis,* and *Pteridium aquilinum* appeared for the first time. Leaf litter had begun to accumulate, with *Poa compressa* scattered throughout these areas. The aspen suckers mapped in 1931 were still present. A large portion of the plot remained bare sand (Fig. 3).

By 1950, *Ceratodon* covered 94.5 percent of the plot (Fig. 8). In addition, *Polytrichum juniperinum,* first appearing as a small clump among the *Ceratodon* in 1942, was present in small amount. Seventeen species of vascular plants were present in 1950, with each species represented by a few individuals, due to the great amount of moss cover. Ten of the species had persisted since 1931, and two since 1940; five species were reported for the first time in 1950 (Table 1). *Arctostaphylos uva-ursi* first appeared between 1940 and 1950. Of the five aspen suckers seen in 1931 and 1940, one persisted and the other four had died. The first tree seedling, of *Quercus rubra*, became established between 1940 and 1950. Fig. 4 shows the area in 1950.

TABLE 1. Changes in the Floristic Composition of the Botany Laboratory Site.

SPECIES[a]	DURATION[b]	YEAR PRESENT			
		1931	1940	1950	1971
Chrysanthemum leucanthemum	P	X			
Verbascum thapsus	B	X			
Poa pratensis	P	X	X		
Lepidium densiflorum (L. virginicum)	A or B	X	X		
Carex rugosperma[c] (C. umbellata)	P	X	X	X	
Agropyron repens	P	X	X	X	
Agrostis gigantea (A. alba)	P	X	X	X	
Carex gracillima	P	X	X	X	
Arabis lyrata	B or P		X		
Rhus Xborealis (R. glabra borealis)	P		X	X	
Pteridium aquilinum (P. latiusculum)	P		X	X	X
Oenothera parviflora (O. muricata)	B			X	
Arctostaphylos uva-ursi	P			X	X
Quercus rubra (Q. borealis)	P			X	X
Hieracium aurantiacum	P			X	X
Solidago juncea	P			X	X
Polytrichum juniperinum	P			X	X
Polytrichum piliferum	P				X
Acer rubrum	P				X
Melampyrum lineare	A				X
Betula papyrifera	P				X
Pinus strobus	P				X
Vaccinium brittonii	P				X
Gaylussacia baccata	P				X
Cladonia rangiferina	P				X
Cladonia mitis	P				X
Cladonia uncialis	P				X
Cladonia cornuta	P				X
Cladonia cristatella	P				X
Cladonia gracilis	P				X
Cladonia verticillata	P				X
Cladonia fimbriata	P				X
Cladonia chlorophaea	P				X
Danthonia spicata	P	X	X	X	X
Panicum meridionale	P	X	X	X	X
Festuca ovina	P	X	X	X	X
Solidago hispida	P	X	X	X	X
Poa compressa	P	X	X	X	X
Populus grandidentata	P	X	X	X	X
Total Number of Species		14	15	18	19[d]

[a]Names applied by Gates in parentheses when different.
[b]A-Annual, B-Biennial, P-Perennial.
[c]The sterile individuals of *Carex* found in the plot are probably of this species. However, because a positive identification could not be made, no *Carex* is listed for 1971 in the table above.
[d]Exclusive of the genus *Cladonia*.

Fig. 2. The area in 1931 showing the amount of bare sand present. From Gates (1952).

Fig. 3. The plot in 1940. Note amount of bare sand still present. From Gates (1952).

In 1971, several major changes in the area were observed. *Polytrichum juniperinum* and *P. piliferum* had almost totally replaced *Ceratodon.* Leach (1931) found that, in sandy soils in Great Britain, *Polytrichum* species follow *Ceratodon* during succession. *Ceratodon,* which covered 94.5 percent of the plot in 1950, was now merely scattered throughout the moss covered areas of the plot. Lichens were also present. Nine species of *Cladonia* were found growing on top of and among the two species of *Polytrichum.* Also, the total

area of moss cover was less than in 1950 (Fig. 9). Nineteen species of vascular plants were recorded. Six of the 14 species seen in 1931 were still present. Of the three new in 1940, only *Pteridium aquilinum* persisted. Eight species were

Fig. 4. The area in 1950. Note the greater number of woody individuals around the area and smaller amount of exposed sand within the plot. From Gates (1952).

Fig. 5. The plot in 1971. Note the increase in bracken fern, bearberry, and aspens. Photo taken July 1971 by Thomas Duncan.

TABLE 2. Key to Symbols Used in Maps of the Plot Shown in Figures 6-9.

Ch-Chrysanthemum leucanthemum	Ox-eye daisy
V-Verbascum thapsus	Common mullein
Pp-Poa pratensis	Kentucky bluegrass
L-Lepidium densiflorum	Pepper grass
R-Rhus ×borealis	Sumac
Pt-Pteridium aquilnum	Bracken Fern
Pc-Poa compressa	Canada bluegrass
Qr-Quercus rubra	Red oak
Ha-Hieracium aurantiacum	Orange hawkweed
Oe-Oenothera parviflora	Evening primose
Au-Arctostaphylos uva-ursi	Bearberry
Ml-Melampyrum lineare	Cow-wheat
Bp-Betula papyrifera	Paper birch
Sj-Solidago juncea	Goldenrod
Cu-Carex rugosperma	Sedge
A-Agropyron repens	Quackgrass
Ag-Agrostis gigantea	Redtop
Cg-Carex gracillima	Sedge

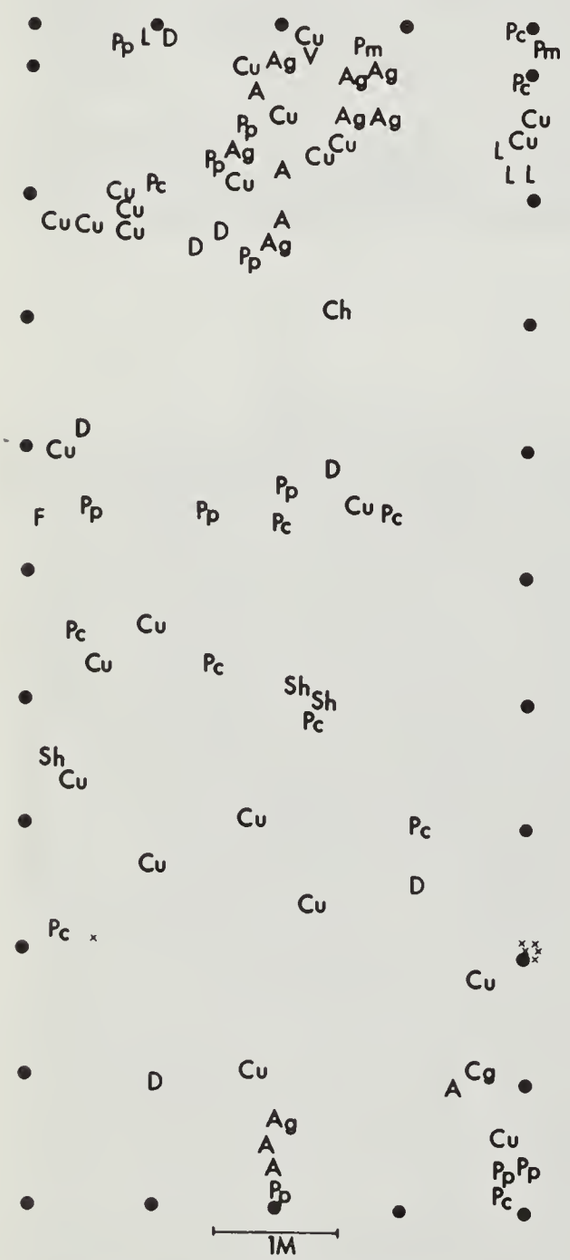

Fig. 6. Map of the plot in 1931. From Gates (1952). See Table 2 for explanation of symbols used in Figures 6-9.

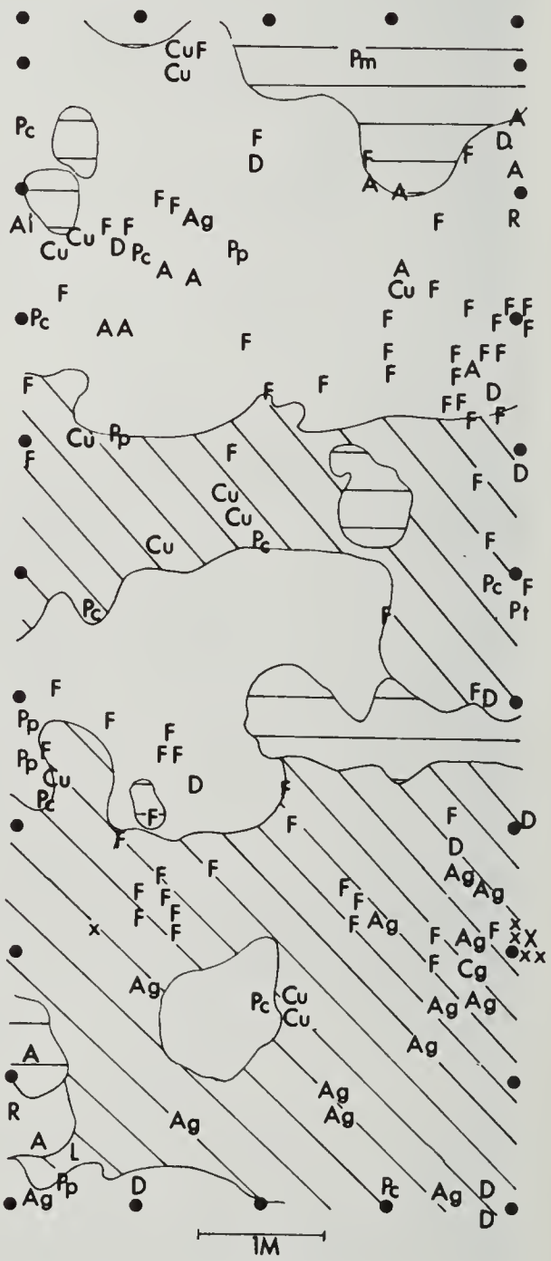

Fig. 7. Map of the plot in 1940. From Gates (1952).

Ar-Acer rubrum	Red maple
C-Carex sp.	Sedge
Ps-Pinus strobus	White pine
Vb-Vaccinium brittonii	Low-bush blueberry
Gb-Gaylussacia baccata	Huckleberry
Hf-Hieracium florentinum	Hawkweed
D-Danthonia spicata	Poverty grass
Pm-Panicum meridonale	Panic grass
F-Festuca ovina	Fescue
Sh-Solidago hispida	Goldenrod
X-Populus grandidentata (sucker)	Large-toothed aspen

●–stake placed by Gates in 1930.
■–a later stake.

Each letter or combination of letters represents the location of an individual or (if preceded by a number) a group of individuals found at that spot. The diagonal lines indicate moss cover. The horizontal lines represent areas of leaf litter, *Poa compressa,* and *Melampyrum lineare.* The vertical lines show the ruts created in 1965 and still evident in 1971.

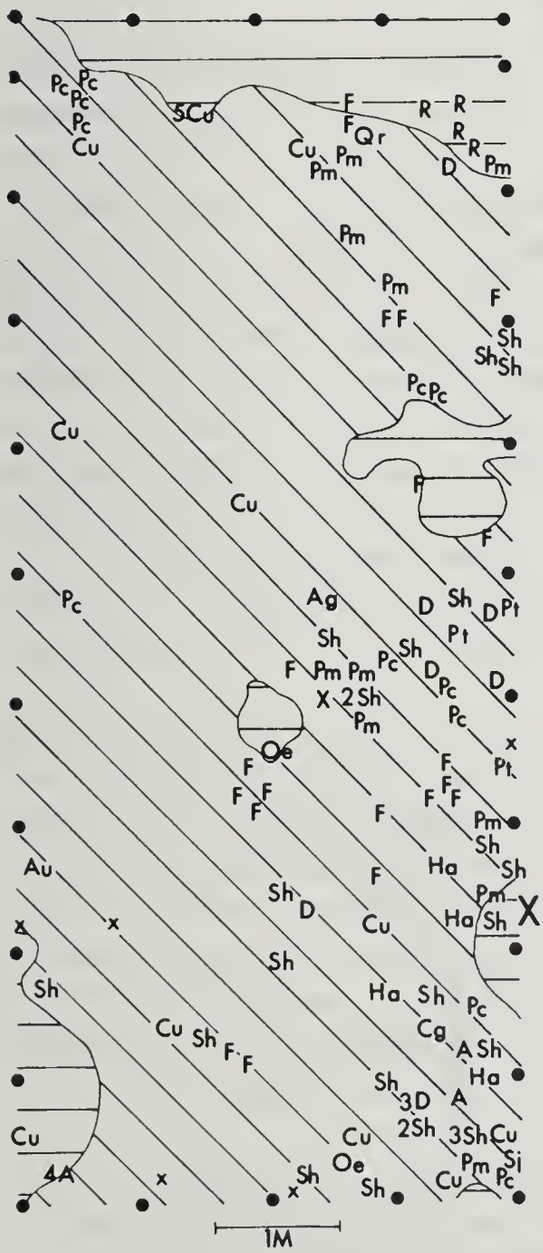

Fig. 8. Map of the plot in 1950. From Gates (1952).

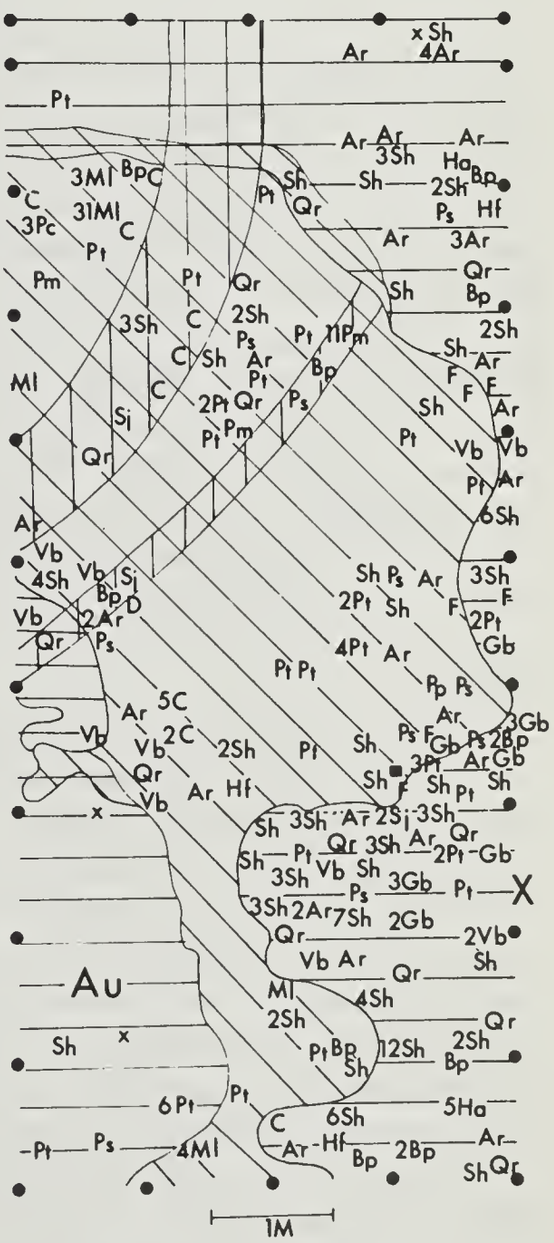

Fig. 9. Map of the plot in 1971. Note decrease in moss cover and increase in area covered by leaf litter compared to 1950.

recorded for the first time in 1971 (Table 1). Of all the species, *Poa compressa* and *Melampyrum lineare* were represented by the greatest numbers of individuals. *Melampyrum lineare,* not present in 1950, became established, rapidly increased in abundance during the last 20 years, and in 1971 was distributed in equal abundance with *Poa compressa* throughout the areas of leaf litter. *Arctostaphylos uva-ursi* had spread considerably since 1950. Three tree species, *Acer rubrum, Betula papyrifera,* and *Pinus strobus,* were present and mapped for the first time. All individuals of these species were seedlings. These species may have become established recently, or they may have invaded the plot several times and not been able to persist. Gates (1952) stated that after 21 years, the site of the Botany Laboratory was still visible. However, in 1971, the site could be located only by careful checking for the stakes placed by him (Fig. 5).

DISCUSSION

The trends of succession discussed here illustrate the edge effect, which is that the composition of the vegetation of an ecotone is a mixture of species of the adjacent habitats. It is also possible, of course, that some species not found in the adjacent habitats can become established in the ecotone between them. Gates (1952) predicted that as the shade of aspens adjacent to the Botany Laboratory site became denser, the area would "become more and more an aspen area as it had been." I would suggest that as the aspens increase in density this ecotonal area between the sandy shore of Douglas Lake and an adjacent stand of red oak, red maple, paper birch, and pine will continue to share species with the two adjacent habitats. Species such as *Arctostaphylos uva-ursi, Oenothera parviflora,* and *Arabis lyrata* are characteristic of the sandy shore along Douglas Lake. Other species such as *Vaccinium brittonii* and *Gaylussacia baccata* are indicative of the adjacent woods. Only *Carex gracillima* has been recorded in the ecotone and not in the adjacent habitats.

Of the three areas mapped by Gates (1952), the site of the Botany Laboratory is the only area in which moss cover developed so rapidly and extensively. The reason is unknown. It could be that the previous use of this site as a roadway before construction of the building so disturbed the area that only the moss, *Ceratodon,* could become established and spread. The marked decline in the abundance and cover of *Ceratodon* during the last 20 years is consistent with its role in succession in other areas. Uggla (1958), in burned areas in Scandinavia, found that *Ceratodon* reached its maximum distribution after some tens of years and then declined rapidly. In this area the same phenomenon has occurred.

The replacement of *Ceratodon* by *Polytrichum juniperinum* and *P. piliferum* appears to have created conditions favorable for the establishment of lichens. The sod-like growth habit of *Ceratodon* and *Polytrichum* makes them efficient sand binders. Because the species of *Cladonia* are not attached in the sand, this stabilization of the site may be necessary before the lichens can successfully become established.

Consistent with Gates' (1946) prediction, decrease in moss cover has been accompanied by an increase in shade-tolerant grasses and forbs. The greater development of leaf litter during the last 20 years appears to be a factor limiting the area of moss cover. With increasing litter accumulation, greater numbers of individuals of vascular plants, particularly *Poa compressa* and *Melampyrum lineare*, are becoming established. The spread of mosses is also limited by the continued vegetative growth of bearberry and other species that creep on the ground.

As noted above, eight species were seen during the first or second year after the site was abandoned, but disappeared soon after. As shown in Table 1, in the years 1931, 1940, and 1950, several species were recorded but once and were not seen in 1971. For all of these adventives, a strong correlation can be seen between duration (annual, biennial, or perennial) and persistence. Of the eight species which appeared during the first two years, all but *Epilobium angustifolium* are annual or biennial. Of the four recorded only once after mapping, i.e., *Chrysanthemum leucanthemum, Verbascum thapsus, Arabis lyrata, Oenothera parviflora,* two are biennials, one either biennial or perennial, and one perennial. These observations suggest that we can expect the same and other such weedy plants to appear from time to time, only to vanish after a short while. Probably some microhabitat disturbance makes it possible for these plants to gain a start. Of the species that have persisted since 1931, none are annuals (Table 1). Thus the most persistent species are primarily perennials and the adventives primarily annuals. Those species which have persisted for but a brief period are primarily biennials. The persistence of the perennials could be, in part, due to the greater capacity for clone formation and other vegetative means of reproduction in this disturbed area.

Although a great change in the composition of the plant cover of this small plot occurred during the last 40 years, one cannot assume that this is a succession unaffected by disturbance. The effects of disturbance here are probably similar to other localities in the Great Lakes region. For example, the sandy shorelines of small lakes are naturally open areas for the travels of deer, and deer-browsing in this area has almost certainly contributed to its disturbance. This browsing would tend to hold back succession (cf. Evans and Cain, 1952). Also, in 1965, two large ruts were created in this plot (Fig. 9) by a tractor which moved a building adjacent to the area. These ruts have temporarily created an increased diversity of microhabitats of open sand. This break in the moss colony probably created conditions suitable for a series of invaders, such as seedlings of certain trees, and some sterile specimens of a sedge (*Carex* sp.). Since the death of Gates in 1955, the area has not been maintained as a preserve. During the last 18 years it has been traversed more or less regularly by people, and such activity tends to slow the progress of succession. Within the last few years, the area along South Fishtail Bay near the site of this study was chosen for the construction of additional housing for the faculty of the University of Michigan Biological Station. By the fall of 1972, the area formerly occupied by the Botany Laboratory had already been disturbed during the construction of a new cottage near the site. In the

future, further disturbance of this type will make subsequent studies impossible. However, other sites studied by Gates (1952) have not yet been disturbed and should be remapped before disturbance similar to that at the Botany Laboratory site occurs.

SUMMARY

Maps of the vegetation for a 38-square-meter plot occupied 1924-1929 by the Botany Laboratory at the University of Michigan Biological Station have shown that:

1. The flora of both vascular and non-vascular plants changed during each interval of time between mapping. Although the number of species was not radically different, the same set of species was not present at each mapping of the area.
2. There is a strong correlation between duration of the plant and its persistence in this area with annuals and biennials being mainly adventives and perennials persisting.
3. Initially the area was covered sparsely by a few individuals of vascular plants with the area mostly bare sand.
4. The first species to become established were weedy colonizers of open exposed areas. Mosses became established later and spread throughout most of the plot. As litter accumulated, vascular plants began to spread. In areas of leaf litter accumulation, greater numbers of individuals of each species have been able to become established. As this continued, tree seedlings became established both in areas of litter accumulation and in the areas of moss cover.
5. Mosses were pioneers of the non-vascular plants with *Ceratodon purpureus* appearing first, forming a colony covering 94.5 percent of the plot in 1950, and then being replaced during the last 20 years by *Polytrichum juniperinum* and *P. piliferum*. In recent years, with the accumulation of leaf litter and continued growth of clones of vascular plants, the moss colony has decreased in coverage of the plot.
6. Lichens have also appeared during the last 20 years. Nine species of the genus *Cladonia* were found growing in and among the members of the moss colony.
7. Disturbance by animals and man has slowed the progress of succession in this area.
8. Assuming little or no disturbance, it may be expected that in the future, aspen suckers and tree seedlings of several species will persist, herbs such as *Poa compressa* and *Melampyrum lineare* will increase, and moss and lichen cover will continue to decrease.

ACKNOWLEDGMENTS

Thanks are extended to Mr. Thomas A. Friedlander for help in the field work and Dr. Dale Vitt for identifying the mosses and lichens. Appreciation is expressed to the University of Michigan Biological Station for the use of their facilities.

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THE GENUS *HERICIUM* IN NORTH AMERICA

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The fruit-bodies of the species in the genus *Hericium* are usually large, and early attracted the attention of numerous artists and mycologists. However, the characters now needed for the separation of species were often overlooked or not described, so that the older records (which in most cases are not supported by specimens) present problems as to their correct identification. Also, it now appears that there are definite limited geographical distributions and host preferences which are still poorly understood, all of which creates some uncertainty as to the correctness of any nomenclatural conclusions when specimens are lacking.

Four species are recognized in North America, with two ranging from coast to coast on deciduous wood; a third species is found on deciduous trunks in the eastern half of the continent, and a fourth is confined to the conifers of the Pacific Northwest. There is also the possibility that American species are not all identical with similar species occurring in Europe. European names are used for three species, but with strong reservations in one instance, due to the lack of adequate critically studied material from many of the ecologically important areas of Europe. In North America, the most adequately collected areas are in Michigan and Idaho, with a fair supply of carefully collected specimens. Other areas are rather poorly represented, either through lack of collectors of the group, or because conditions are unfavorable for species to grow.

Hericium Pers. ex S. F. Gray. Nat. Arr. Brit. Pl. 1: 652. 1821 (Based on *Hericium* Pers. Neues Mag. Bot. 1: 109. 1794.) Not *Hericium* Fries. Syst. Orb. Veg. 88. 1825.

Hydnum tribe *Merisma* subtribe *Genuina* Fr. Syst. Mycol. 1: 408. 1821.

Medusina Chevallier. Fl. Gen. Env. Paris. 278. 1826.

Friesites Karst. Meddel. Soc. Fauna Fl. Fenn. 5: 41. 1879.

Dryodon Karst. Rev. Mycol. 3: 19. 1881.

Manina Banker. Mycologia 4: 275. 1912 (Incorrectly attributed to Scopoli by Banker).

Basidiocarp fleshy or fibrous fleshy, nodular, tuberculiform or branched, attached to substrate by a more or less rooting base; spines mostly subulate, pendent, rarely some horizontal. Spores almost globose to ovoid, minutely roughened to almost smooth, hyaline, amyloid. Context amyloid; clamps and gloeocystidia present. Growing on fallen trunks or standing trees.

Type: *Hericium coralloides* (Scop. ex Fries) S. F. Gray. Nat. Arr. Brit. Pl. 1: 652. 1821.

Persoon (1794) introduced *Hericium* as a genus with *H. coralloides* as the only species. In 1797 he expanded it to include *Hydnum clathroides* Pallas (1773), a species described as "cinerascens" and "subulis filiformibus unilateralibus" in contrast to *H. coralloides* "subulis terminalibus subfasciatis reflexis." Among the references under the latter is one to Bulliard's (1788) Pl. 390 as "(Icon. optima)," since indicated as representing the type of *H. ramosum.* Persoon (1801) again revised *Hydnum*, and under "*D. Hericium*" presented as No. 25 *Hydnum coralloides* with *H. clathroides* Pallas as var. β, and again including Bulliard's Pl. 390 in the references.

Fries (1821) validated the generic name *Hydnum* and the names *H. coralloides* and *H. clathroides* Pallas as the only two species in tribe *Merisma* subtribe *Genuina.* Under *H. coralloides* Scop., he listed Schaeffer Pl. 142, Sowerby Pl. 252, and *H. ramosum* Bulliard Pl. 390. Also included were *H. laciniatum* Leers, *H. crispum* Scop., *H. abietinum* Schrad., and *H. muscoides* Schum. The habitat for this group was "ad truncos Fagi, Abietis, passim." It was a grouping of what we now consider branched forms of *Hericium* with pendent spines.

Gray (1821) was the first to revise *Hydnum* Fr. after the designated nomenclatural starting date, and the wording on p. 652 is as follows:

XLIV. 286. HERICIUM. Persoon. *Spine-stool.*

Thallus clublike, simple or branched; *prickles* covering every part.—wholesome.

Hericium coralloides. *Coral-like spine-stool.*

Thallus large, much branched; branches crowded, bent in; *prickles* terminal, rather bundled.

Hydnum coralloides *Sowerby Fungi*, 252; *Persoon Syn.* 252 [error for 563].

In woods, upon oaks and other trees.

Esculent.

This publication validated the generic name, and limited the type to a *H. coralloides* having "tufted spines" and "on oaks and other trees" (deciduous?).

Banker (1906) recognized Gray's description as one that applied to a

very common species with large spores on deciduous wood in eastern North America, and the name *H. coralloides* has been accepted for it since that time. Donk (1956) and Maas Geesteranus (1959) have both published comprehensive synonymies with discussions, and have reached conclusions on various aspects of the problems affecting the genus.

KEY TO THE SPECIES OF *HERICIUM*

1. Sporophore complexly branched with short spines seldom over 2 cm 2
1. Sporophore usually a large fleshy tubercle with long pendent spines (up to 4 cm); spores 5.5-6.0 × 5.0-5.5 μ . . . . . .3. *H. erinaceus*
   2. Branches mostly fine (occasionally coarse) with spines pendent, continuous along lower surfaces (comb-like); spores 3.1-5.0 × 3-4 μ . . . . . .2. *H. ramosum*
   2. Branches coarse, spines in tufts and terminal on the ends of branches, not continuous along lower surfaces; spores larger 3
3. Growing on frondose wood (eastern North America), spores 5.5-7.0 × 4.5-6.0 μ . . . . . 1. *H. coralloides*
3. Growing on coniferous wood (western), spores 4.5-5.5 × 4.0-4.5 μ . . . . . 4. *H. abietis*

1. *Hericium coralloides* (Scop. ex Fries) S. F, Gray. Nat. Arr. Brit. Pl. 1: 652. 1821. Fig. 1.

   Hydnum coralloides Scop. ex Fries. Syst. Mycol. 1: 408. 1821, in part. (Based on *Hydnum coralloides* Scop. Fl. Carniol 2: 472. 1772.)

   Hydnum alpestre Pers. Mycol. Europ. 2: 151. 1825.

   Dryodon coralloides (Scop. ex Fries) Karst. Rev. Mycol. 3: 19. 1881.

   Manina coralloides (Scop. ex Fries) Banker. Mycologia 4: 276. 1912. (Generic name incorrectly attributed to Scopoli.)

Basidiocarp up to 30 cm across, main branches stout and branching repeatedly, white, becoming cream-colored in age; one collection (*Smith 81095*) vinaceous pink when young; context fleshy, brittle to tough, white, amyloid in Melzer's reagent; odor and taste mild, not distinctive.

Spines 5-15 mm long, stout, tapering to a slender tip, in terminal clusters on the ends of branches and from lateral nodules, white becoming cream-colored in age.

Stipe represented by a short pseudorhiza that soon branches, or as a tubercle with short branches, attached by strands penetrating the rotting wood.

There is no color reaction when KOH is applied to the tissues, but they give an amyloid reaction with Melzer's reagent.

Spores 5.5-7.0 × 4.5-6.0 μ, white, globose to subglobose, finely roughened to almost smooth, amyloid. Basidia clamped, 25-30 × 5-6 μ; gloeocystidia sharp-pointed or beaded on tips, 6-9 μ wide, frequently projecting 25 μ above hymenium, filled with oily contents that may ooze out as droplets in KOH mounts, arising from deep within the context. The oozing droplets often harden into conidia-like shapes.

The trama is monomitic; hyphae up to 20 μ wide, variably inflated, thick-walled, with lumen almost closed in some, and septa usually with clamps. The amyloid reaction of the tramal hyphae in Melzer's reagent can vary in intensity.

The habitat is old logs, dead stubs, or cankers on living trees with heart

Fig. 1. *Hericium coralloides* ×3/4 Harrison 9695. Spines terminal or bunched.

rot. It has been reported on *Fagus, Acer, Carya* and *Quercus.* Collections usually recorded as occurring on rotting deciduous logs. In Michigan, most commonly reported on *Acer* spp., but *Fagus* is the most common host over its entire range. *Populus* has been considered a common substrate, but oddly enough, there are no collections on this host in the University of Michigan Herbarium. The species is limited in North America to east of the the Great Plains, and north of North Carolina and Tennessee.

Collections have been examined from Maine to Minnesota, and as far south as North Carolina and Tennessee. Miller and Boyle (1943) reported it as rare in Iowa, and Maneval (1937) recorded it in Missouri. Canadian specimens have been examined from Ontario and Nova Scotia. Bisby (1938) reports it from Manitoba. It is common throughout the state of Michigan, and 41 collections from 12 countries have been studied. It is so common in the state that it is no longer a curiosity, even to amateurs, and few specimens have reached the herbarium in recent years.

A major problem in establishing host and distribution records is the confusion in species names. The species concept for *H. coralloides* as having large spores was established by Banker (1906) and has been followed by North American mycologists ever since. It has not been followed by European mycologists except Maas Geesteranus. The situation has been complicated by numerous misidentifications of *H. ramosum* as *H. coralloides,* and by the use of the name *Hericium caput-ursi* (Fr.) Banker for the tuberculate growth forms of both species. A further source of confusion is the presence on western conifers of *H. abietis* (Weir ex Hubert) K. Harrison, and the fact that there is a parallel pattern of growth forms common for all species of *Hericium*. The tuberculate form of *H. ramosum* was named *Hydnum caput-ursi* by Fries (1863). Banker (1906) incorrectly applied the same name to the similar form of *H. coralloides* on deciduous wood, at the same time transferring it to *Hericium*. Peck (1899) named a short-spined variation *H. caput-ursi* var. *brevispineum.* Banker (1906) placed this in synonymy with *H. caput-ursi.* There are also erect forms with secondary branches and spines radiating like the branching of conifers. A collection with this form on conifers was named *Hydnum alpestre* by Persoon (1825). Similar "alpestre" forms are known for *H. ramosum* (fig. 7) and *H. abietis,* so that the most reliable character for identification of specimens with odd patterns of spines is the difference in spore sizes among the three species.

It was not realized until recently that there is a very important difference in the hosts for *Hericium coralloides* in North America and in Europe. Snell et al. (1956, p. 169) report the occurrence of *H. coralloides* on *Tsuga* sp., the only record known to them of a *Hericium* on conifers in eastern North America. In Europe Maas Geesteranus (1971, p. 54) has stated, "to my knowledge true *H. coralloides* in the north temperate zone has only been found on conifers." Following this statement he attempted to explain one collection seen from India, reported on oak, as possibly an inaccurate observation of the host. He apparently overlooked the numerous American records of *H. coralloides* on deciduous wood, dating from the time of Banker

(1906). Recently it has been possible to examine the hydnums in the National Fungus Collections, Beltsville, Maryland. There are two sets of G. Linhart, Fungi hungarici exsiccati. Cent. IV, issued in 1885. One packet of number 442 contains *Hydnum coralloides* on *Fagus*, collected Aug. 1885. It is typical of *H. coralloides* and has similar-sized spores (see table of comparative measurements under *H. abietis*). The other packet contains a mixed collection of *H. ramosum* and *H. coralloides.* No scraps of the woody substrate were found to confirm the identity of the host of either collection, but the presence of *H. ramosum,* which is found exclusively on deciduous wood, is evidence that strongly supports a conclusion that the host was deciduous for all specimens.

There is a strong possibility that in Europe *H. coralloides* on deciduous wood may be all but eliminated by modern forestry methods. In my personal experience, *H. coralloides* was common on *Fagus grandifolia* killed by the introduced European beech coccus and nectria canker in Nova Scotia during the 1930's. Now that large beech logs are no longer available in the province as a habitat, *Hericium coralloides* has become extremely rare or possibly extinct. (There are no records of it on maple logs in the region.) There is only one record (which was in 1963) of *H. coralloides* having been collected in the province during the past twenty years. In Michigan, when conditions are favorable for a fruiting, the abundance of *Hericium* is in proportion to the number of decaying tree trunks in the forests and woodlots. These observations can only suggest what may be taking place in Europe with modern advances in methods of salvaging forest wastes. So, with these possibilities, we are accepting the circumscription of Gray that *H. coralloides* can occur on oaks in Europe, and that the American species was correctly identified by Banker.

2. *Hericium ramosum* (Bull. ex Mérat) Letellier. Hist. Desc. Champ. 43. 1826. Figs. 2, 3, 4, 5

Hydnum ramosum Bull. ex Mérat. Nouv. Fl. Envir. Paris, Deux. Ed. 1: 37. 1821. (Based on *H. ramosum* Bulliard. Herb. France, pl. 390. 1788.)

Hydnum coralloides Scop. ex Fr. Syst. Mycol. 1: 408. 1821, in part.

Hydnum caput-ursi Fr. Monog. Hym. Suec. 2: 278. 1863.

Friesites caput-ursi (Fr.) Karst. Meddel. Soc. Fauna Fl. Fenn. 5: 41. 1879.

Dryodon caput-ursi (Fr.) Karst. Rev. Mycol. 3: 19. 1881.

Hericium laciniatum Leers ex Banker. Mem. Torrey Bot. Club 12: 114. 1906.

Hericium caput-ursi (Fr.) Banker. Mem. Torrey Bot. Club 12:118. 1906. (Misapplied.)

Manina flagellum Scop. ex Banker. Mycologia 4: 276. 1912.

Manina caput-ursi (Fr.) Banker. Mycologia 4: 277. 1912.

Type represented by *Hydnum ramosum* Bulliard. Herb. France, pl. 390; 1788.

Basidiocarp up to 26 x 15 cm, usually much smaller, intricately

branched; branches usually slender but as much as 3 cm thick in larger specimens; white, at maturity outwardly tinged with cream color; context soft, brittle, white; old specimens may stain light vinaceous when cut. Odor and taste mild, not distinctive.

Spines up to 8 mm, when in tufts up to 2.5 cm, fine, close, tapering, pendent from tips and lower surface of branches, white, cream-colored in age; branches often with numerous abortive spines on sides, and traces of them on upper surface.

Stipe a tubercle covered with coarse tomentum if base is exposed, attached laterally to wood, dividing immediately into numerous branches, white, becoming creamy.

There is no color reaction when KOH is applied to surface or context, while Melzer's reagent produces an amyloid reaction.

Spores 3.1-5.0 x 3-4 μ, white, subglobose to ovoid, finely roughened to almost smooth, amyloid; basidia clamped, 30 x 5-6 μ, 4-spored; gloeocystidia protruding from the hymenium, 5-6 μ wide, arising in the subhymenium.

Hyphae of the trama clamped, monomitic, amyloid but reaction varies in intensity, interwoven, thick-walled, inflated; lumen nearly closed in some.

Hericium ramosum is found on decaying logs of frondose species in the forests of North America and Europe. This species is the most widespread and, in many parts of North America, the one most commonly collected.

Material examined: Fifty-eight collections in Michigan from 12 counties, most commonly on *Acer* spp., frequent on *Fagus* and *Betula*, single collections on *Ulmus, Carya,* and *Fraxinus.* It is the only species seen on cottonwood and aspen (*Populus* spp.) in the west. Single collections on *Alnus* (Oregon) and live oak (California), and in Alaska on *Betula* and *Populus.* In Canada, reported by Bisby et al. (1938) from Manitoba; specimens examined from Alberta, Nova Scotia, Ontario, Saskatchewan, Northwest Territories, and the "alpestre form" from Quebec. Probably found as far north as there are log-sized frondose trees for a habitat. The 1962 Annual Report of the Forestry Laboratory at Calgary lists *H. ramosum* on white spruce. This collection (*CFB 5310*) was borrowed from the Northern Forest Research Centre, Edmonton, Alberta, and fortunately, small fragments of wood still adhered to the sporophore. Prof. Stephen B. Preston, School of Natural Resources, University of Michigan, identified the wood as deciduous and most probably *Populus* sp. Seven other collections from northwestern Canada from the Forestry Centre were all *H. ramosum,* either on *Populus* or *Betula* spp. In Europe, *H. ramosum* is usually identified as *H. coralloides,* and mycologists there have been slow to accept the proper name. The recent report of *H. ramosum* on conifers in the state of Washington (Hall & Stuntz, 1971) is not supported by specimens.

This is usually a finely branched species (fig. 2), that was known by Banker (1912) as *Manina flagellum,* and by Miller and Boyle (1943) as *Hericium laciniatum.* The latter name has been widely adopted in North America. Maas Geesteranus (1959) pointed out that another name, *H. ramosum,* had priority. This name has been accepted in North America. Recently (1971) he proposed a still older name *H. clathroides* Pallas as

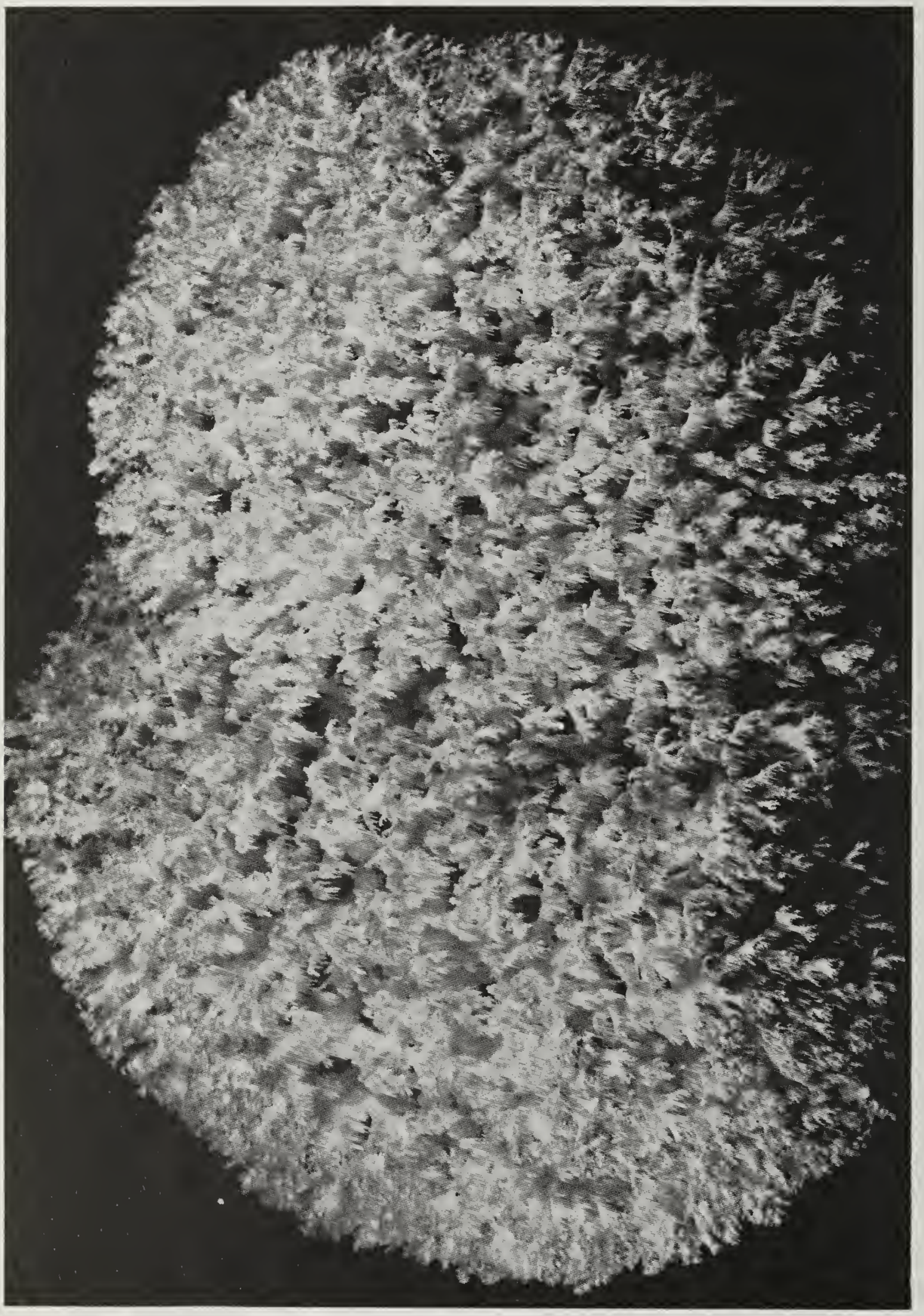

Fig. 2. *Hericium ramosum* ×2/3 Harrison 9565. Spines on lower sides of branches, lacy appearance.

Fig. 3. *Hericium ramosum* × 1 Harrison 6237. Photo A. H. Smith. Spines on lower side of branches.

Fig. 4. *Hericium ramosum* X1 1/3 Harrison 6314A, Photo A. H. Smith. Spines mature, closely spaced, continuous along under side of branches.

correct. However, Pallas' description is for a species that is "cinerascens," and was collected in a pinetum. Harrison (1973) has argued that this name-change should not be followed. No collections have been recognized as this species since the time of Pallas. Nikolajeva (1962), the authority on *Hericium* in Russia, merely mentions it as a species published by Fries, and does not use the name or place it in synonymy with any species or varieties described by her. Asia is too large, and too poorly known mycologically, to say that such a species as described by Pallas does not exist. Thus the name is better maintained separately in case such a species is found eventually.

H. ramosum is recognized by the continuous rows of fine spines pendent from the lower surface of the branches (figs. 3 & 4), and by spores that only reach the size of the smaller spores in either *H. coralloides* or *H. abietis.* There are numerous growth forms (see *H. coralloides* for further discussion). If the branches grow more or less upright (fig. 5), the spines project from all surfaces giving an open bushy appearance. There is also a rare compact solid

Fig. 5. *Hericium ramosum* ×1 Harrison 6314. Photo A. H. Smith. "Alpestre" type of growth; spines projecting from all surfaces.

form known as *H. caput-ursi* (Fr.) Banker, but this name has been used in North America for a similar growth form of *H. coralloides.* The rows of spines along the underside of the branches, and the small size of the spores, must be used to correctly identify the species.

3. *Hericium erinaceus* (Bull. ex Fr.) Pers. Mycol. Europ. 2: 153. 1825. Fig. 6
Hydnum erinaceus Bull. ex Fr. Syst. Mycol. 1: 407. 1821. (Based on *Hydnum erinaceus* Bulliard. Herb. France, pl. 34. 1780.)
Hydnum caput-medusae Bull. ex Fr. Syst. Mycol. 1: 409. 1821.
Dryodon erinaceus (Bull. ex Fr.) Karst. Bidr. Känn. Finl. Nat. Folk. 37: 92. 1882.
Manina cordiformis Scop. Diss. Sci. Nat., Pl. Subterr. pl. 10. 1772.
Manina cordiformis Scop. ex Banker. Mycologia 4: 277. 1912.
Type represented by *Hydnum erinaceus* Bulliard. Herb. France, pl. 34. 1780.

Basidiocarp an ovoid to lobed tubercle, solid or lacunose, up to 25 cm wide, attached laterally; upper surface a tangle of coarse agglutinated strands of mycelium; white becoming yellowish and finally brownish. Margin of pileus indefinite, but marked by the bases of long pendent spines. Context fleshy, tough, watery, concolorous; odor and taste mild.

Spines 1-4 cm long, pendent, beard-like, covering the sides. These are formed in a line as though the rows of spines originated in sequence during the enlargement of the tubercle.

Stipe represented by a tough rooting attachment arising within the woody substrate.

No color reaction with chemicals is available from fresh specimens. When KOH was applied to dried material there was no reaction; with Melzer's reagent, context surface and spores were amyloid, context usually amyloid but may not show any darkening in some sections.

Spores 5.5-6.8 x 4.5-5.6 μ, subglobose, finely roughened to smooth; basidia 25-40 x 5-7 μ, 4-spored; gloeocystidia arising in subhymenium, up to 7 μ wide, with dense contents exuding as oily appearing droplets in KOH.

Hyphae of the trama 3-20 μ in diameter, inflated or not, thick-walled, at times the lumen almost closed, interwoven, giving rise to gloeocystidia in the spines. Interweaving hyphae 3-10 μ thick with some clamps, branched and thick-walled.

H. erinaceus is widely distributed but locally rare in North America. Reported from Florida to California in the south, and in the north from Washington, southern Michigan, and New York state. More commonly reported from the southern states than either *H. coralloides* or *H. ramosum.* It is considered as being associated with a heart rot of oaks, occasionally on other frondose species, and is usually found growing from knotholes or cracks on living trees. It is recorded on *Fagus* in a number of states, on *Acer* spp. (Washington), *Eucalyptus* (California) and *Platanus* (Virginia). Only five collections have been made in Michigan, all in southern counties. In Canada, a report by Harrison (1961) is now considered to be the tuberculate form of *H.*

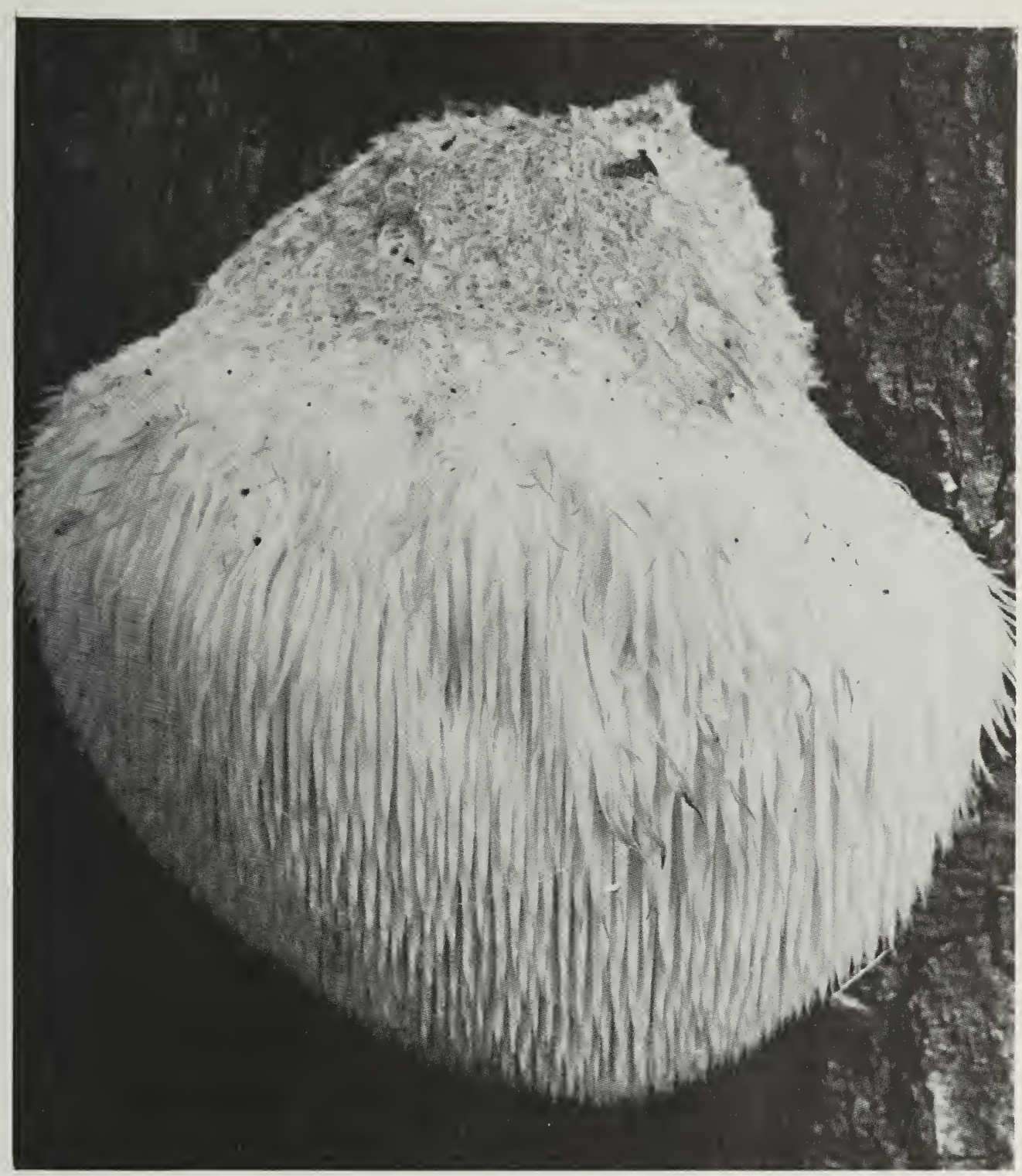

Fig. 6. *Hericium erinaceus* ×1 Sept. 1950. Photo A. H. Smith. (From *The Mushroom Hunter's Field Guide,* by permission of the University of Michigan Press.)

coralloides. No collections have been seen from Ontario and Quebec. Collections have been examined from eleven states.

This distinctive fungus is well illustrated in the literature, although good specimens are rare in herbaria, as specimens often turn dark brown or mould during preparation. This species occasionally has a tendency to divide into stout branched forms (Bulliard's *Hydnum caput-medusae*) that might be mistaken for a stout form of *H. coralloides* as the spores are the same size. The basic strand-like structure of the hericiums can be seen best in this species

in collections that show cavities or gaps in the surface, or when the fruit-body is sectioned. The strands in the tramal tissue radiate, twisting together to form fused bundles within the more or less solid context. The individual strands eventually separate and hang downward to form the long pendent spines. The spore surface of *H. erinaceus* has been examined using the scanning electron microscope and illustrated (Pegler & Young, 1972). The light microscope shows the surface as ranging from smooth to roughened, while the SEM photographs show variations that are usually small ridges, suggesting that other species might be examined profitably.

4. *Hericium abietis* (Weir ex Hubert) K. Harrison. Canad. Jour. Bot. 42: 1208. 1964. Fig. 7

Hydnum abietis Weir ex Hubert. Outl. For. Path., 305. 1931.

Hericium weirii A. H. Smith. Mushr. Hunt. Field Guide, rev. ed. 60. 1963. (nom. nud.)

Basidiocarp up to 75 x 25 cm, either a solid tubercle or branched compactly or openly (numerous forms exist); white to yellowish, sometimes pinkish buff when young, tending to stain yellowish when bruised. Context firm, pallid. Odor and taste mild.

Spines up to 1 cm long, very short and stout when young, pointed, on ends of nodules on the branches or in tufts on the ends.

Stipe lacking, represented by large, solid, occasionally massive, tubercle attached laterally to the wood by rooting strands. The basal mycelium is interwoven with rhizomorphic strands; hyphae on surface of basal tubercle nonamyloid, prominently clamped, 2-3 μ wide, cells long, walls thin.

Chemical reactions have not been obtained on fresh material. No KOH reaction when dried; Melzer's reagent gave amyloid reaction to tramal context, branches, and spines.

Spores 4.5-5.5(-6.0) x 4.0-4.5(-5.0) μ, subglobose, white, finely roughened to smooth, strongly amyloid with walls appearing to vary in thickness, and the roughest reacted most strongly to Melzer's; centers of spores of one collection were dextrinoid. Basidia 5-7 x 25-30 μ, with walls irregular wavy; cystidia represented by flexuous, slightly clavate, hyphal end cells. Gloeocystidia 8-12 μ; ends of oleiferous hypha traced for 200 μ to union with thick-walled hyphae; exposed ends in hymenium more or less moniliform, thin-walled, usually burst in Melzer's reagent and exuding oily contents. Hymenium and subhymenium nonamyloid, dull yellow in Melzer's; subhymenium compact, 20-30 μ thick, consisting of a layer of thin-walled generative hypha 3-4 μ in diameter.

Hyphae of the basidiocarp amyloid, flexuous, often bifurcating broadly, with angle as between extended thumb and first finger, interwoven, variable in width, often swollen where ends of cells meet, usually clamped at the septa, thick-walled, with lumen filled in some.

This fungus causes a typical "white pocket rot" of *Abies grandis* (Dougl.) Lindl., *A. lasiocarpa* (Hook.) Nutt., *A. procera* Rehd., *Picea engelmannii* Parry ex Engelm., *Tsuga heterophylla* (Raf.) Sarg., *Pseudotsuga menziesii* (Mirb.) Franco in the Pacific Northwest. In Canada, it was reported

Fig. 7. *Hericium abietis* ×1 1/4 Harrison 6299, Photo A. H. Smith. Details of spines at ends of branches.

from British Columbia by Bier (1949) as *Hydnum* sp. causing a "long pitted trunk rot" of western hemlock and true fir. Foster and Foster (1951) also reported it as a cause of a rot of western hemlock. In Alaska, *Hydnum abietis* was reported by Englerth (1947) as the cause of a serious rot of western hemlock, and in one instance of a rot of *Picea sitchensis* (Bong.) Carr.

All material that has been examined from California, Idaho, Oregon, and Washington has been on conifers. The recent statement of Maas Geesteranus (1971) that the species known as *H. coralloides* in Europe is found only on conifers, will require careful collecting of all species of *Hericium* and comparison of typical collections again. It is unfortunate that the exact conifer species affected in Europe cannot be ascertained from the literature available to me.

In North America, this species is the giant among hericiums. It varies considerably in size, apparently depending on the bulk of the tree trunk affected, and whether moisture conditions were favorable for maximum growth. The color of the young fruit-body varies from salmon buff to white, and stains yellowish in age. It was thought that the white fruit-bodies of *H. ramosum* and *H. coralloides* were distinctive, but Smith's collection 81095 of *H. coralloides* was vinaceous when young, indicating that colored strains of the latter exist in Michigan.

Maas Geesteranus has annotated various collections on western conifers in the National Fungus Collections at Beltsville as *H. coralloides*, although he noted that it had smaller spores than the species on conifers in Europe. Harrison (1964) when publishing on *Hericium abietis,* pointed out the spores were intermediate in size between *H. ramosum* and *H. coralloides*, and recognized it as a distinct species. Recently, it has been possible to compare specimens held in the National Fungus Collections at Beltsville. Three of those selected were from conifers in Europe, three were on conifers in Idaho, and one on *Fagus* in Hungary. The measurements obtained are given in the following table:

H. coralloides on coniferous wood in Europe.

Kreiger 1158	4.6-5.6 × 4.2-5.6 μ av. 25 spores 5.3 × 4.9 μ
A. Pilát	5.2-6.0 × 4.8-6.0 μ av. 25 spores 5.5 × 5.3 μ
F. Bubak	4.8-6.0 × 4.6-5.6 μ av. 25 spores 5.5 × 5.1 μ

H. coralloides on Fagus in Europe.

G. Linhart 442	5.0-6.2 × 4.8-5.6 μ av. 20 spores 5.6 × 5.3 μ

H. abietis on coniferous wood in Idaho.

J. R. Weir 16017	4.6-5.4 × 4.0-4.8 μ av. 10 spores 4.9 × 4.5 μ
J. R. Weir 16020	4.4-5.6 × 4.0-4.8 μ av. 25 spores 4.9 × 4.6 μ
J. R. Weir (19 Sept. 1916)	4.4-5.6 × 4.0-4.8 μ av. 40 spores 4.9 × 4.45 μ

The spore measurements from the collection on *Fagus* are within the range of those on coniferous wood, indicating that the host range is broader than stated by Maas Geesteranus.

The difference in the average spore size between European *H. coralloides* and *H. abietis* is apparent in this table and is considered taxonomically significant. In addition, *H. abietis* differs in normally being larger and usually having a colored fruit-body, when compared with *H. coralloides.* Also, *H.*

abietis causes a destructive heart rot of commercially valuable coniferous timber. It is highly significant that *H. abietis* does not attack deciduous wood in the Pacific Northwest, and that *H. coralloides* (with one exception) is not found on coniferous wood in the east. Therefore, *H. abietis* is being maintained as a species distinct from the *H. coralloides* forms of North America and Europe.

SUMMARY

The host ranges and distributions of the species of *Hericium* in North America are summarized as follows: *H. erinaceus* is only found on deciduous wood throughout the region. It is the most common species in the south and is usually found on oaks associated with a heart rot. *H. ramosum* is also found on deciduous wood throughout the region. This is the common species on *Populus* spp. in the northwest, and there are many misidentifications of it as *H. coralloides*. *H. coralloides* is common on deciduous wood (one record on coniferous wood) and only occurs in eastern North America. No collections have been seen from west of the Great Plains. In Europe, *H. coralloides* has been reported as only on coniferous wood. (One exception is recorded from Hungary.) In spite of the differences in hosts, the two forms are considered to be one species. *H. abietis* is found causing a destructive rot of conifers west of the Great Plains. No specimens have been found on deciduous wood. Because of the difference in spore size, color of the fruit-body, destructive capacity on western conifers, and failure to attack deciduous trees, *H. abietis* is maintained as a distinct species.

ACKNOWLEDGMENTS

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Publication of Interest

THE POLLINATION OF FLOWERS. By Michael Proctor & Peter Yeo. Collins, London, 1973. 418 pp. + 4 color & 56 black and white plates. £4.00 [= ± $9.60]. This latest volume (no. 54) in The New Naturalist series, illustrated with 200 photographs and numerous drawings, deals primarily with British plants, as would be expected in a series designed to survey British natural history. But the principles are broad and other examples are freely cited. The bulk of the work is devoted to the reciprocal adaptations of flowers and flower-visiting insects, but there is a substantial chapter on wind and water pollination as well as one on self-pollination and apomixis. Concluding chapters on "Pollination in Plant-Breeding and Commerce" and "The Evolution and Ecology of Pollination" round out the text. A bibliography and author index and a full subject index, including all plants mentioned, add to the usefulness of a fascinating volume.

Nature education feature --

FUNGI OF LOWER HURON METROPOLITAN PARK IN WAYNE COUNTY, MICHIGAN

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Eastern Michigan University, Ypsilanti

A preliminary survey of fungi was conducted during the summer months of 1970 at the Lower Huron Metropolitan Park, Wayne County, Michigan. Two nature trails exist in the park, and the fungal survey was organized according to the trails open to visitors.

A total of 112 specimens were collected in the park between June 1 and August 31. Habitat data, specimen numbers, specimen descriptions, and collection dates were recorded; and spore prints were made. Both habitat and indoor photographs were taken and sample specimens were dried and catalogued.

The study is illustrative of a botanical investigation conducted in a public park within a metropolitan area. Fungi were selected for this study; however, other groups of plants could serve as the subject matter for botanical surveys within a relatively small area near home.

PARK DATA

The park covers an area of 1,000 acres. The Huron River flows through the park, which is situated between the cities of Belleville and Flat Rock. The fungal survey primarily centered around the two maintained nature trails associated with the Nature Center. Both trails were originally designed to encompass a variety of habitats typical of the park area. Bridges were built across small intermittent streams in order not to disturb natural drainage patterns. The Pawpaw Trail was constructed in 1953 and the Bobwhite Trail was made in 1962. Each trail is covered to a width of 4 to 5 feet with wood chips which are replenished when needed. An attempt is made to maintain the natural habitats along the trails.

The circular Pawpaw Nature Trail is about 3/4 mile in length and is next to the Huron River. The trail area is moderately well to imperfectly drained and subjected to occasional spring flooding. Soil of this trail area is considered alluvial with a surface layer 6 to 36 inches deep consisting of a sandy loam to silt loam. The subsurface is composed of stratified sand and silts. Trees and shrubs that dominate the vegetation include *Acer saccharinum, A. saccharum, A. negundo, A. nigrum, Asimina triloba, Carpinus caroliniana, Celtis occidentalis, Cercis canadensis, Crataegus* sp., *Fraxinus nigra, Gymnocladus dioica, Juglans cinerea, Juniperus virginiana, Liriodendron tulipifera, Morus rubra, Platanus occidentalis, Populus deltoides, P. tremuloides, Prunus serotina, Pyrus coronaria, Quercus bicolor, Tilia americana,* and *Ulmus americana.* Other vegetation includes annual and perennial plants in the form of woodland flowers and vines. In a few areas there is a thin covering of mosses.

The Bobwhite Trail is located in an upland wooded area. Many semipermanent areas of water create a swampy habitat in the spring and following heavy rains in the summer months. Several intermittent streams cross the area. Some open grassy areas occur along the trail, while the more typical upland areas are devoid of swampy spots. Most of the 1 1/2 mile Bobwhite Trail area is composed of a flood plain soil, Wauseon fine sandy loam. This lake plain soil has a surface layer of 6-10 inches. The subsoil is 1 1/2 to 3 1/2 feet deep consisting of loamy fine sand to fine sandy soil which is supported by clay to silty clay loam. The soil is poorly drained and registers a pH of 5.7 to 6.5. One area of the trail near a parking lot is identified as Tedrow loamy soil. This soil has a surface layer of 4 to 7 inches of loam supported by noncoherent sands. The soil is imperfectly drained with a pH of 5.5 to 7.0.

Tree species dominate the vegetation of the Bobwhite Trail. Mosses were also found along the trail, forming a dense mat in many areas. Ferns were also abundant along sections of the trail in addition to other herbaceous plants. Trees and shrubs found in the area include *Acer saccharinum, A. rubrum, Carpinus caroliniana, Carya cordiformis, Cornus florida, Crataegus* sp., *Fraxinus nigra, Juglans cinerea, Liriodendron tulipifera, Nyssa sylvatica, Platanus occidentalis, Populus deltoides, P. grandidentata, Prunus serotina, Quercus alba, Q. bicolor, Q. palustris, Salix nigra, Sassafras albidum,* and *Tilia americana.*

Comparing the two trails as to vegetation other than fungal species, oaks are more abundant on the Bobwhite Trail and elms are lacking. However, some elm logs are in the Bobwhite area. The Bobwhite Trail is closer to climax than the Pawpaw area. In the Pawpaw Trail area an invasion of red cedar occurred with succession taking place in a one-time open grassy area along the river. Many shrubs are found in the Pawpaw area, indicating an earlier stage of succession compared to the other trail area. An abundance of mosses and ferns are found in the Bobwhite area while the Pawpaw trail has few mosses and only a few scattered ferns.

TABLE 1. Paw Paw Trail Fungal Species

June

Collybia velutipes (Fries) Quélet
Coprinus micaceus Fries
Favolus alveolaris (Fries) Quélet
Gymnosporangium globosum Farlow
Marasmius elongatipes Peck
Marasmius rotula (Fries) Fries
Polyporus adustus Fries
Polyporus dichrous Fries
Polyporus versicolor Fries
Psathyrella larga (Kauffman) Smith
Schizophyllum commune Fries
Stereum ostrea (Fries) Fries
Trametes malicola Berkeley & Curtis
Tremella intumescens Quélet
Xylaria polymorpha (Persoon) Fries

July

Clavaria vermicularis Scopoli
Coprinus micaceus Fries
Lepiota rhacodes (Vittadini) Quélet

August

Clavulina cristata var. *coralloides* (Fries) Corner
Coprinus micaceus Fries
Hygrophorus psittacinus Fries var. *psittacinus*
Lenzites betulina (Fries) Fries

TABLE 2. Bobwhite Trail Fungal Species

June

Calocera cornea Fries
Daedalea quercina Fries
Favolus alveolaris (Fries) Quélet
Fomes applanatus (Wallroth) Gillet
Gymnoconia peckiana (Howe) Trotter
Hemitrichia clacata (Persoon) Rastafinski
Humarina testacea (Mougeot) Seaver
Hygrophorus cantharellus (Schweinitz) Fries
Lactarius subdulcis var. *rufus* Fries
Lycogala epidendrum Fries
Lycogala flavofuscum (Ehrenberg) Rostkovius
Mycena leaiana (Berkeley) Saccardo
Panus rudus Fries
Pleurotus ostreatus (Fries) Kummer
Polyporus arcularius Fries
Polyporus paragamenus Fries
Polyporus versicolor Fries
Schizophyllum commune Fries
Sphaerospora trechispora (Berkeley & Brenckla) Saccardo
Stereum complicatum (Fries) Fries
Tremella intumescens Quélet

July

Aleuria cestrica (Ellis & Everhart) Seaver
Badhamia utricularis (Bulliard) Berkeley
Ramaria aurea (Fries) Quélet
Clavulina cinerea (Fries) Schroeter
Collybia dryophila (Fries) Kummer
Collybia eatonae Murrill
Coprinus lagopus Fries
Delicatula integrella (Fries) Fayod.
Fomes igniarius (Fries) Kickx
Helvella crispa var. *alba* Fries
Hygrophorus conicus Fries
Hygrophorus laetus Fries
Hygrophorus parvulus Peck
Laccaria amethystina (Bolton) Peck
Laccaria laccata (Fries) Berkeley & Broome
Lactarius vellereus Fries
Lepiota cristata Albertini & Schweinitz
Lycoperdon perlatum Persoon
Marasmius oreades (Fries) Fries
Marasmius resinosus Peck
Marasmius semihirtipes Peck
Oudemansiella radicata (Fries) Singer
Panellus atrocoerulecus var. *griseus* Peck
Pleurotus ostreatus (Fries) Kummer
Pluteus cervinus (Fries) Kummer
Polyporus dichrous Fries
Polyporus picipes Fries
Polyporus planellus (Murrill) Overholts
Polyporus pubescens Fries
Russula emetica (Fries) S. F. Gray
Russula ochroleuca Fries
Steccherinum adustum (Schweinitz) Banker
Stemonitis splendens Rostkovius
Stereum complicatum (Fries) Fries
Stereum ostrea (Fries) Fries
Thelephora terrestris Fries
Tremella albida Fries
Tylopilus indecisus (Peck) Murrill

August

Amanita verna (Fries) Quélet
Phyllotopsis nidulans (Fries) Singer
Collybia dryophila (Bulliard) Quélet
Humarina rubens (Boudier) Seaver
Hygrophorus flavescens (Kauffman) Smith & Hesler
Lactarius vellereus Fries
Lycoperdon perlatum Persoon
Metatrichia verparium (Batsch) Nannenga-Bremekamp
Pleurotus ostreatus (Fries) Kummer
Tricholomopsis platyphylla (Fries) Singer

FUNGI FOUND IN THE TWO TRAIL AREAS

The collected specimens were identified according to standard works. Species of fungi are listed in alphabetical order for the month when they were found actively growing. Pawpaw Trail fungal species are listed in Table 1, while species of the Bobwhite Trail are found in Table 2. Single collections of *Corticium, Cortinarius, Hydnum, Lactarius, Marasmius, Mycena,* and *Tremella*

were also found but not identified to species due to the condition of the specimens.

Climatological data were obtained from the Metropolitan Airport, Detroit, located 5 miles from the survey site. Temperature and precipitation data tabulated below for May through August include the month before mycological collections were made. "Normal" temperatures and rainfall are an average of data for the same months during the previous 38 years.

METEOROLOGICAL DATA

	Average 1970 Temperature	Departure From Normal	Monthly 1970 Precipitation	Departure From Normal
May	60.9 F	+3.3 F	3.01 inches	+0.27 inches
June	68.4	+0.5	3.90	+0.18
July	72.6	+0.2	3.30	-0.10
August	72.1	+1.3	2.75	-1.19

Data on temperature indicate that May produced the greatest change. The temperatures for May averaged higher than normal while other months showed less variation. The collection period of May and June was above average in total rainfall, July was slightly below average, and August was more than one inch below normal. The dry months probably reduced the abundance of fleshy fungi in the park.

CONCLUSIONS

The Bobwhite Trail was more productive in the number of species collected compared to the Pawpaw Trail. Diversity and density of vegetation as well as the water-holding capacity were greater in the trail region yielding more fungal species. Temperature increases and decreases in rainfall also were factors in the abundance of fungi of the area. Subsequent surveys of the Lower Huron Metropolitan Park should reveal a more abundant and possibly more diversified fungal flora.

ACKNOWLEDGMENTS

The authors wish to express appreciation to Dr. A. H. Smith, University of Michigan, Ann Arbor, and to Dr. C. J. Alexopoulos, University of Texas, Austin, for assistance in species identification. Appreciation is also extended to Mr. W. F. Hopkins, Chief Naturalist, Huron Clinton Metropolitan Authority, for permission to survey the park areas.

Editorial Notes

The Michigan Botanical Club mourns the passing of Walter P. Nickell, one of our honorary members, on January 2, 1973, at the University of Tennessee Memorial Hospital. A noted ornithologist, naturalist, photographer, and teacher, he had served on the staff of Cranbrook Institute of Science from 1935 until his recent retirement, when he moved to Tennessee.

The March number (Vol. 12, No. 2) was mailed March 8, 1973.

Beal Botanical Garden Centennial

This year Michigan State University celebrates the centennial of the W. J. Beal Botanical Garden, founded in 1873 by Professor William James Beal, dedicated scientist, teacher, and environmentalist. This oldest continuously active botanical garden in North America originally consisted of 140 plots of grasses and clovers used for teaching scientific agriculture. In 1877 the scope of the plantings was broadened to serve more generally the instructional program in plant sciences. At Dr. Beal's retirement in 1910 the Garden occupied 2.1 acres and included more than 2,100 species.

Beal's vision of the Garden as an important instrument for developing discerning, self-reliant investigators, as well as his emphasis on a pleasing design incorporating both native and exotic plants, has been faithfully perpetuated by his successors. The Garden now occupies nearly six acres and includes over 5,000 species organized in systematic, economic, ecological, and landscape sections. It is a fitting and enduring memorial to this remarkable general practitioner in the plant sciences who made many pioneering contributions to botany, forestry, horticulture, crop science, and landscape architecture.

Several important events celebrating the Centennial have been scheduled for May. These include the dedication of a Centennial Plaque in the Garden and a state meeting of the Michigan Botanical Club on May 13. Other activities include "garden days" on several Sundays in May, radio and television programs, and guided tours to other campus features relating to Beal, including the Beal-Darlington Herbarium, the Beal Pinetum, the Horticulture Gardens, and Sanford Natural Area. The Governor is expected to declare May 12-19 as William James Beal Week. Special displays are being provided in the University Museum and Library illustrating Beal's research and writings on hybrid corn, seed longevity, the grasses of North America, the Michigan Flora, and other subjects.

CONTENTS

Two Misunderstood Species of *Gyromitra* (False Morel) in North America
Kent H. McKnight 147

The Lichen Flora on *Ulmus americana* in Northern Michigan
Russell L. Mahoney 163

Forty Years of Succession on an Abandoned Building Site at the University of Michigan Biological Station
Thomas Duncan. 167

The Genus *Hericium* in North America
K. A. Harrison. 177

Publication of Interest 194

Nature Education Feature–
Fungi of Lower Huron Metropolitan Park in Wayne County, Michigan
J. K. Weyer & P. A. Volz 195

Editorial Notes 199

Beal Botanical Garden Centennial. 199

(On the cover: The Calypso or Fairy-slipper orchid,
Calypso bulbosa, *photographed near Wilderness State Park,*
Emmet County, Michigan, by William H. Anderson, June 20, 1971.)

33
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THE NORTHERN LIMIT OF THE DISTRIBUTION OF THE MOCKERNUT HICKORY

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Bucknell University, Lewisburg, Pennsylvania

INTRODUCTION

There is considerable confusion in literature about the northern limit of the mockernut hickory, *Carya tomentosa* (Poir.) Nutt. [in some older books, *C. alba* (L.) K. Koch or *Hicoria alba* (L.) Britt.]. Thus Preston (1948), Munns (1938), and Harlow and Harrar (1958) on their maps show the northern limits as southern Maine, New Hampshire, Vermont, Ontario, and Michigan, whereas Harlow (1957) gives the range as Massachusetts to northeastern Kansas, suggesting that none of the above regions are included. Most books give three or four of these regions; e.g., Fernald (1950) gives the northern range as southern Vermont, Ontario, and Michigan, but Brockman (1968) shows on his map New Hampshire and Vermont, not Ontario or Michigan. The detailed maps of Little (1965, 1971) show the mockernut in scattered locations in New Hampshire, Vermont, Ontario, and Michigan. All of the above publications also correctly include eastern and central New York state.

In a recent paper (Manning, 1973) I have shown that the mockernut does not occur in Maine, New Hampshire, or Vermont, and that the northern limit in New England is Massachusetts. This paper will discuss only Ontario and Michigan.

The following authors place the mockernut in southern Ontario and southern Michigan: for Ontario, Fox and Soper (1954), Dodge (1910, 1914), Morton (1956), White (1968), Hosie (1969); for Michigan, Beal (1905), Otis (1931), and Bingham (1945). Fox and Soper (1954) list the following localities in Ontario from either collections or published records: Kent Co., Prairie Siding, sight record of Soper, in 1950; Lambton Co., Squirrel Island, Dodge (1910); Essex Co., Point Pelee and Pelee Island, Dodge (1914), and Windsor, Macoun (1886); Welland Co., Niagara Falls, Macoun (1893); and uncertain county, shore of Lake Erie, July 27, 1877, specimen at Ontario Agricultural College. Otis (1931) states that in Michigan the mockernut occurs in the "Southern Peninsula as far north as Grand Rapids and Flint," apparently basing his distribution on Beal (1905).

It is probable that recent authors who give the distribution of the mockernut in Ontario base their opinions on the writings of Macoun and Dodge. Macoun (1886, p. 433), in his catalogue of Canadian plants, not only recognized *Carya alba*, shell-bark hickory, *C. porcina*, pig-nut hickory, and *C. amara*, bitter-nut hickory, but also *C. tomentosa*, white heart hickory. About this species he says: "Niagara peninsula from Lake Ontario to Lake Erie and extending westward to Windsor and an indefinite distance beyond." Macoun

(1893) states that *Carya alba, C. amara, C. porcina*, and *C. tomentosa* are to be found in close proximity to Niagara Falls. Dodge (1910, p. 48), with reference to Lambton County, Ontario, says: "One large tree of the mocker nut hickory was noticed on Squirrel Island, probably its extreme northern limit for this region." Dodge (1914, p. 38) records mockernut as follows: "Very common at Point Pelee and on Pelee island, Put-in-Bay island."

IDENTIFICATION

In my New England paper (Manning, 1973) I gave a key separating the five species of *Carya* which occur in New England. *C. laciniosa* was not included as it is not native in New England. A more complete key was given in Manning (1950). It might be well to repeat here the characteristics of *C. tomentosa*, as recognition of the species is one of the main problems in studying the distribution. The mockernut has been primarily confused with the shagbark, *C. ovata* (Mill.) K. Koch, bitternut hickory, *C. cordiformis* (Wang.) K. Koch, and big shellbark hickory, *C. laciniosa* (Michx.) Loud.; it has occasionally been confused with the pignuts, *C. glabra* (Mill.) Sweet and *C. ovalis* (Wang.) Sarg. Any of these species may have seven hairy leaflets. Brief notes on all of these species may therefore be of value.

The mockernut is characterized by having (5) 7-9 leaflets, never 5 alone (unless one picks a weak atypical lateral branch); lower surfaces of the leaflets always fascicled hairy and with yellow scales (lepidote); serrations of the leaflets usually ciliate but lacking special dense subapical tufts of hairs; rachis and twig often but not always prominently fascicled hairy with curly hairs; twig dark brown; branchlets stout; true terminal buds in winter subglobose, gray silky hairy without outer dark brown bud-scales (these having fallen off in late autumn); husk of fruit medium thick, dehiscent to the base of the fruit; nut brownish, angled, the style-like tip stout; bark of trunk tight, furrowed, not shaggy.

Carya ovata has usually 5, rarely 7, leaflets, with dense subapical tufts of hairs on most of the serrations; the winter terminal buds are elongate, ovate, with outer usually narrow dark brown bud-scales present; the bark on older trees is shaggy. *C. cordiformis* has definitely yellow buds. *C. glabra* and *C. ovalis* have mostly slender glabrous twigs and branchlets, usually glabrous leaves and thin husks; the bark may be tight or somewhat shaggy; occasionally the 5-7 leaflets and the rachis may be hairy and very rarely even the twig may be hairy. *C. laciniosa*, the closest vegetatively to *C. tomentosa*, has 7-9 large leaflets, these fascicled hairy beneath, fascicled hairy to glabrate rachises, and often fascicled hairy twigs; the branchlets are stout; the hairs are finer than in the mockernut; the critical distinctions are buff (light orange) winter twigs, elongate (broadly ovate) terminal buds in winter with outer dark brown bud-scales present; very large fruit and nuts; shaggy bark.

True overwintering terminal buds (absent on fruiting twigs) and notes on bark are important in the identification of hickories and these are usually lacking on herbarium specimens.

METHODS OF STUDY

I have examined specimens from a number of herbaria including the principal ones in Michigan and Ontario (see Acknowledgments). In addition, I have corresponded with several people who have knowledge of the trees of Ontario. It was unfortunately not possible to undertake field work in Michigan and Ontario. In order to get a better view of the broader northern distribution of mockernut I have checked the detailed published maps of the neighboring states and have received revised maps for two of them; I had previously checked herbarium material of these states, though I did not check identifications for specific areas shown on the maps.

RESULTS

With two special exceptions, discussed below, I have found no specimens of mockernut hickory from Michigan and Ontario among the many herbarium specimens which I have examined. Several specimens were incomplete and difficult to name, some consisting of only a few leaflets, but these were evidently not *C. tomentosa*. Several sheets collected in Michigan and Ontario originally identified as *Carya alba* or *Hicoria alba* all proved to be some other species such as *C. cordiformis, C. ovata,* or *C. ovalis*. Except for the Macoun specimen discussed below, I found no herbarium specimens which could be the basis for the published records of Macoun and Dodge. Dr. E. G. Voss, of the University of Michigan herbarium, which includes Dodge's herbarium, states that Dodge often did not collect specimens but merely depended upon sight records, which were not always correct in identification. Although both Macoun and Dodge recognized other species of *Carya*, as well as *C. tomentosa*, there is still the probability that they confused the species with another one.

Correspondence with individuals in Ontario who have had considerable experience with the trees of the province indicates that no one has positively seen the mockernut in Ontario recently. The following notes are from personal correspondence received in 1969. Mr. R. C. Hosie, Professor Emeritus of Forestry, University of Toronto, says that neither he nor Dr. J. H. White had ever found the mockernut in Ontario. Furthermore, in 1948, he and other forestry officials made a special effort to locate a mockernut tree in the province but were unsuccessful. Mr. Hosie has informed me that the broad distribution of the species in southern Ontario given by him in *Native Trees of Canada* (Hosie, 1969) is based not on new information but on old unauthenticated publications of Macoun, Dodge, and others. Dr. R. D. Ussher, Park Naturalist at Rondeau Provincial Park, Morbeth, Ontario, states that he does not know the whereabouts of a mockernut. Dr. F. H. Montgomery, retired Professor of Botany at University of Guelph, states that in his years of travel in Ontario he has never seen a mockernut; he also reports that Mr. Monroe Landon, of Simcoe, one of the best naturalists of southern Ontario, has never seen a mockernut along Lake Erie. Dr. James S. Pringle, of the Royal Botanical Gardens at Hamilton, does not believe that the records given by Fox and Soper, mentioned above, are dependable, and he feels that the broad

distribution given by Macoun suggests that he was confusing the tree with some other species; furthermore, he believes that the records of Dodge, apparently unauthenticated by specimens, are also unreliable. Mr. Bert Miller of Fort Erie had heard of a large stand of mockernut at Vineland, west of St. Catherines. He travelled to Vineland and went with woodsmen to 8 or 10 woodlots but found only the common hickory; furthermore, he spent 3 days near Fort Erie looking for mockernut; unfortunately the leaves and twigs of the large trees of hickory he found were beyond his reach but he believed that the trees were bitternut hickory. Professor G. J. Lemieux of Université Laval has informed me that he photographed a tree, whose young growth was hairy, in the peninsula of Niagara near Cayuga, but he did not collect specimens and the identification is very uncertain.

Dr. L. O. Gaiser, who sent her specimens of hickories to me for identification from Lambton County, Ontario, did not locate any mockernut in that county (Gaiser, 1966).

Thus, there seem to be no positive records of the mockernut in Ontario or Michigan. There are, however, the following two uncertain specimens:

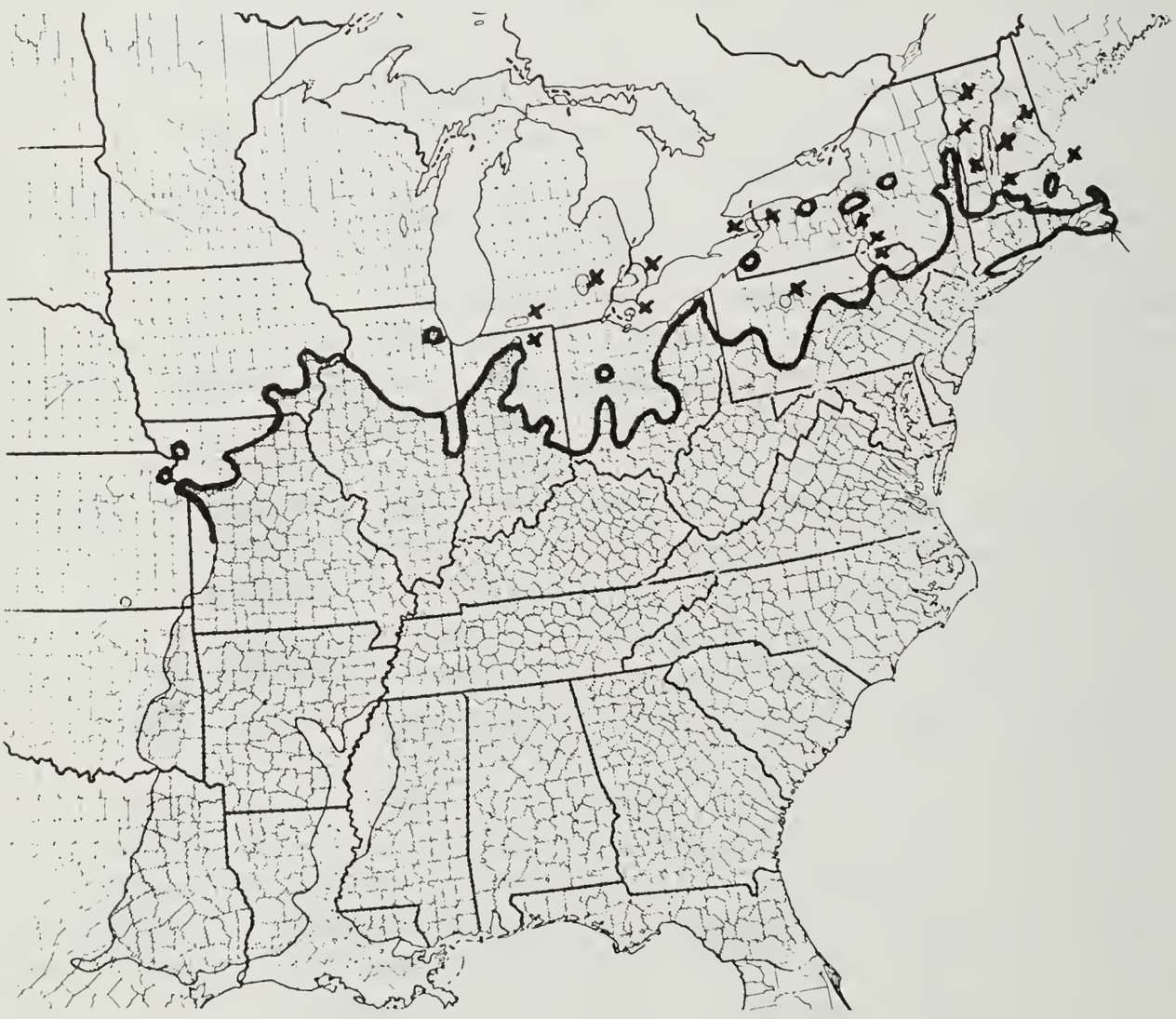

Fig. 1. Corrected map of the distribution of the mockernut hickory, *Carya tomentosa*, based on the map of Little, 1971. The correct limits are indicated by a heavy line; each incorrect location given by Little is denoted by an "X" beside the area on the map.

Macoun 11601, collected July 27, 1877, along the shore of Lake Erie (presumably in Ontario) and *Farwell 1149* from Belle Isle in the Detroit River, Wayne County, Michigan. Macoun's collection (OAC) may have been collected in Hastings County, Ontario, as on that same date he collected a specimen of *C. ovata* from Belleville, Hastings County, but there is no certainty about the county for the collection of the mockernut. The label on Farwell's specimen (BLH) gives the date as October 19, 1893. However, the specimen must have been collected in May as it is in flower; thus labels must have been mixed and this specimen may not be from Belle Isle at all. Both specimens are quite hairy, with 7 leaflets, as in *Carya tomentosa*, but there are no winter terminal buds, no notes about bark, no fruit, and it is possible that these are incomplete specimens of *C. laciniosa, C. ovata* (though no tufts seem present), or *C. ovalis* (a few Ontario collections of *C. ovalis* are highly unusual in having hairy twigs, corresponding to *C. ovalis* var. *obcordata* f. *vestita* Sargent). It is possible that these two specimens could represent records for mockernut for Michigan and Ontario (the species formerly very rare and now extinct), but because much uncertainty exists about identification and locality and because these are the only known collections it seems best to consider the distribution as not including Ontario and Michigan. It is possible of course that future collecting might turn up definite specimens.

The map (Fig. 1) included in this paper is the excellent detailed map of Little (1971) which I have corrected, removing Maine, New Hampshire, Vermont, Ontario, and Michigan. I have also corrected the distribution in the adjoining states, following the latest maps for New York, Pennsylvania, Ohio, Indiana, and Illinois. It is obvious that the mockernut does not come as close to Ontario and Michigan as was formerly believed. Thus there are no records near Buffalo, N.Y., nor in the Erie Islands, Ottawa County, Ohio. I have not found any specimens of mockernut in the herbarium of the Stone Laboratory in the Erie Islands. The record reported by Core (1948) from South Bass Island was based on a probably erroneous record in E. L. Moseley's Sandusky Flora (1899, p. 70) (Core, personal communication); a specimen collected on South Bass Island by H. Martin in 1914 (GH) and originally called *C. tomentosa* is *C. ovata*. Neither Dr. E. L. Core nor Dr. R. L. Stuckey has seen a mockernut hickory in the Erie Islands.

In conclusion, the erroneous published ranges for the mockernut in Ontario and Michigan are due in part to incorrect identification, in part to copying of previous erroneous publications, and in part to the confusion in herbaria and books caused by the name *Carya alba* which has been applied by some botanists to the shagbark, by others to the mockernut. The name *Carya alba* has now been discarded as a "nomen ambiguum."

The range of the mockernut at our present knowledge should not include Maine, New Hampshire, Vermont, Ontario, or Michigan. The northern limit of the range should be stated as Massachusetts, New York, Ohio, Indiana, Illinois, southeastern Iowa, Missouri. Or this might be condensed to "eastern Massachusetts to southeastern Iowa and Missouri." The total distribution might be stated as "eastern Massachusetts to Florida west across eastern

and central New York and northern Ohio to southeastern Iowa, Missouri, southeastern Kansas, eastern Oklahoma, and eastern Texas."

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I wish to thank the curators of the following herbaria for their cooperation in lending specimens: MICHIGAN: The University of Michigan, Ann Arbor (MICH); Michigan State University, East Lansing (MSC); Cranbrook Institute of Science, Bloomfield Hills (BLH); Wayne State University, Detroit (WUD); ONTARIO: National Museum of Natural Science, Ottawa (CAN); Plant Research Institute, Department of Agriculture, Ottawa (DAO); University of Toronto, Toronto (TRT); Ontario Agricultural College, University of Guelph, Guelph (OAC); Royal Botanical Gardens, Hamilton (HAM); McMaster University, Hamilton (MCM). I have checked for mockernut specimens of Michigan and Ontario at McGill University, Montreal, Quebec (MTMG); Gray Herbarium (GH) and Arnold Arboretum (A), Cambridge, Mass.; U.S. National Herbarium, Smithsonian Institution, Washington, D.C. (US). I have also identified material for the late Dr. L. O. Gaiser from Lambton County, Ontario (Gaiser, 1966). Specimens were also recently sent to me for examination from the Buffalo, New York, Museum of Science, and from the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio.

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A WESTWARD EXTENSION OF HEMLOCK IN WISCONSIN

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and Duane J. Lahti
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University of Wisconsin–Superior

In discussing the range of hemlock, *Tsuga canadensis* (L.) Carr., in northern Wisconsin, Curtis (1959) stated that it extends as far westward as western Sawyer and Bayfield Counties. Goder (1962) reported on hemlock reproduction and survival on its border in northern Wisconsin, and provided a map for this border. This map does not show *Tsuga canadensis* present in Douglas County. While conducting field studies in 1968 and 1969 the authors located two areas of naturally-occurring hemlock in Douglas County (Fig. 1). It is the purpose of our paper to report this westward extension to the known range of eastern hemlock. In addition, we hope the discovery of these new areas may provide added insight into factors limiting the distribution of hemlock.

The study areas (A and B) are located in the township of Bennett, approximately 30 miles south of Superior, Wisconsin, on highway 53. The geographic location is T46N, R11/12W. The most easterly of the two study areas is 10 miles west of the Douglas County - Bayfield County lines (approximately 25 miles west of the *Tsuga* border of Goder) and is on the western border of the Brule River State Forest.

Study area A (see Figure 1) is approximately 1 mile east of Highway 53, at Emmanuel Church and the Cemetery, on both sides of the range 11 and range 12 dividing line, extending north for nearly 1 mile on both sides of the range 11 and range 12 dividing line, and south for less than ¼ mile.

Study area B is 0.5 miles west of the intersection of county roads P and L and extends north for approximately 2 miles along the road which follows

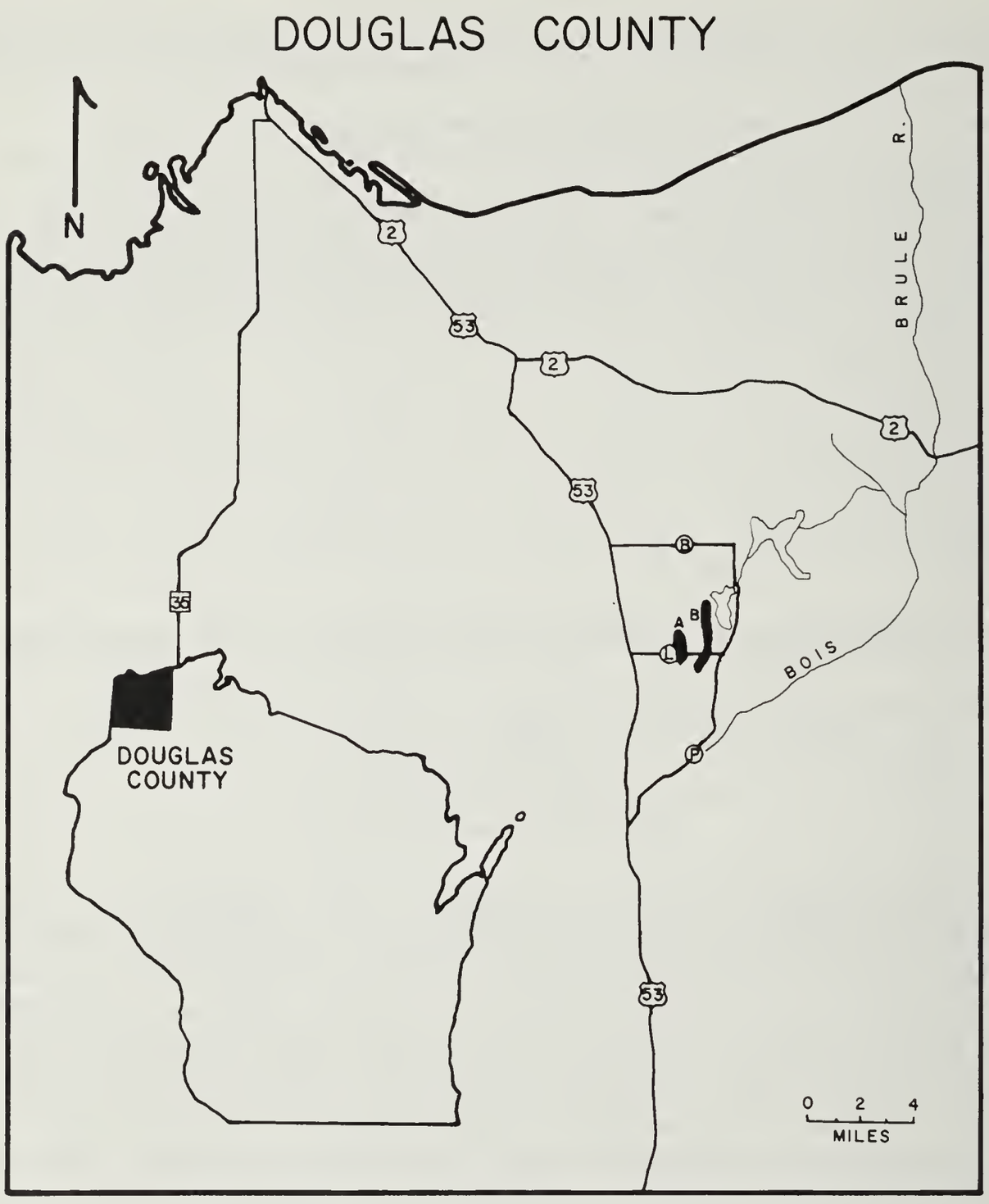

Fig. 1. Geographic distribution of hemlock stands in Douglas County, Wisconsin.

the western boundary of the Brule River State Forest and south-southwest for more than 1 mile.

The two areas located in this study are a mixture of hemlock with other species found in the northwestern Wisconsin region (in both upland and lowland environments), and which result in some of the upland forests being similar to the northern hardwoods forest type. They are not "stands" of hemlock, as one would conceive them in much of eastern United States. Species found in the lowland areas included black spruce (*Picea mariana*), white spruce (*Picea glauca*), white pine (*Pinus strobus*), yellow birch (*Betula lutea*), black ash (*Fraxinus nigra*), balsam fir (*Abies balsamea*), tamarack

(*Larix laricina*), white cedar (*Thuja occidentalis*), and willow (*Salix* sp.). Upland area species included ironwood (*Ostrya virginiana*), sugar maple (*Acer saccharum*), silver maple (*Acer saccharinum*), yellow birch (*Betula lutea*), white birch (*Betula papyrifera*), basswood (*Tilia americana*), white ash (*Fraxinus americana*), bigtooth aspen (*Populus grandidentata*), trembling aspen (*Populus tremuloides*), balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), jack pine (*Pinus banksiana*), and red oak (*Quercus rubra* var. *borealis*). The area as a whole is thus not ecologically homogeneous.

Substantial portions of the two study areas are dotted with low mounds of glacial materials, resulting in somewhat irregular topography. The hemlock trees of these areas are found almost exclusively on hardwood knobs. On the margin of the areas, the hemlocks are found associated with common lowland species, as listed above.

The average diameter of 213 hemlock trees measured was 10.3 inches, and the trees were approximately 40 feet high on the average. One tree as large as 20 inches d.b.h. was found. Hemlock normally attains a height of 60-70 feet with a 5-6 foot diameter (Harlow, 1957). As is typical of hemlock, growth rate has oscillated tremendously, and in many of the individual hemlock trees the increment cores contained growth rings spaced so closely together that counting them was difficult. Conversely, in the same core, rings were counted up to ¼ inch apart. Those trees growing at the margin of the swamps and the knob areas generally appear taller. With some exceptions, reproduction is sparse or lacking.

Hemlock in the study areas appear to be very sensitive to soil moisture content. The greatest numbers of mature large trees and young saplings were found adjacent to abundant water supplies. These water supplies were small depressions and routes of surface water runoff. Very few mature trees were observed on the knobs away from abundant water supplies. Overabundance of water may also serve to limit the hemlocks as none were found in the swampy areas which surround the study area.

Generally, the trees in the study areas were in poor condition. Insect damage is considerable as evidenced by the numerous woodpecker holes. Many of the trees had broken or dead tops, and dead punky centers. Van Dersal (1938) states that Hemlock is adversely affected by humus fires. The oldest tree studied was 148 years old, so it was assumed that the last severe burn on this particular site occurred no more recently than 148 years ago. No charcoal was found in the increment cores of the trees sampled.

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THE BRYOPHYTES OF AMNICON FALLS STATE PARK, DOUGLAS COUNTY, WISCONSIN

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This paper reports on a survey undertaken to provide a checklist of the bryophytes of Amnicon Falls State Park and to provide additional records of bryophytes in Douglas County, Wisconsin.

Amnicon Falls State Park is the newest of three state parks in Douglas County, located in the northwestern corner of Wisconsin (Fig. 1). The park is situated about 13 miles southeast of Superior near Highway 2 (T48N, R12W). The original park site, known as Bardon Park, was a gift to the state by Douglas County in 1961 and consisted of 164 acres in two lots. Since that time, six additional acquisitions increased the park to 816 acres. The state added campsites after its acquisition and made other general improvements including a new bridge over the river and surfaced roads. A covered bridge, a local attraction originally used for Saturday night dances in the community, has been rebuilt after it was damaged by vandals.

The major attraction of the park is the interesting geological phenomenon to be found on the site. Straddling the steeply dipping Douglas Fault, the park provides an opportunity to view the contact between the Late Precambrian Keweenawan lava flow and the younger, northern sandstones of the Orienta formation which underlie the Superior basin at this point. Thus, the Amnicon River courses over basaltic lava flows and then cuts through sandstones on its way to Lake Superior (Mengel, 1971).

The vegetation of the park is aspen second growth, characteristic of logged-over areas in northern Wisconsin, with the exception of a small stand of red pine (*Pinus resinosa*) which is located on and adjacent to a small island formed by a fork in the Amnicon River. With the exception of this small area of pine, the forests have been logged twice. The first logging, around the turn of the century, removed the pine. Later, in the early 1940's, pulp was harvested from the area.

A ravine some 15 feet below the surrounding topography carries a small stream into the river near the picnic area. This provides a sheltered, moist habitat for many mosses of sandstone preferences. The basaltic rocks which are exposed in and around the park area provide additional habitats ranging from dry exposed rock surfaces to shaded, moist rock ledges.

The park was visited at regular intervals during the 1969 growing season. Collections were also made during the following three years to add additional records. The most intensive collecting was focused on the original park site

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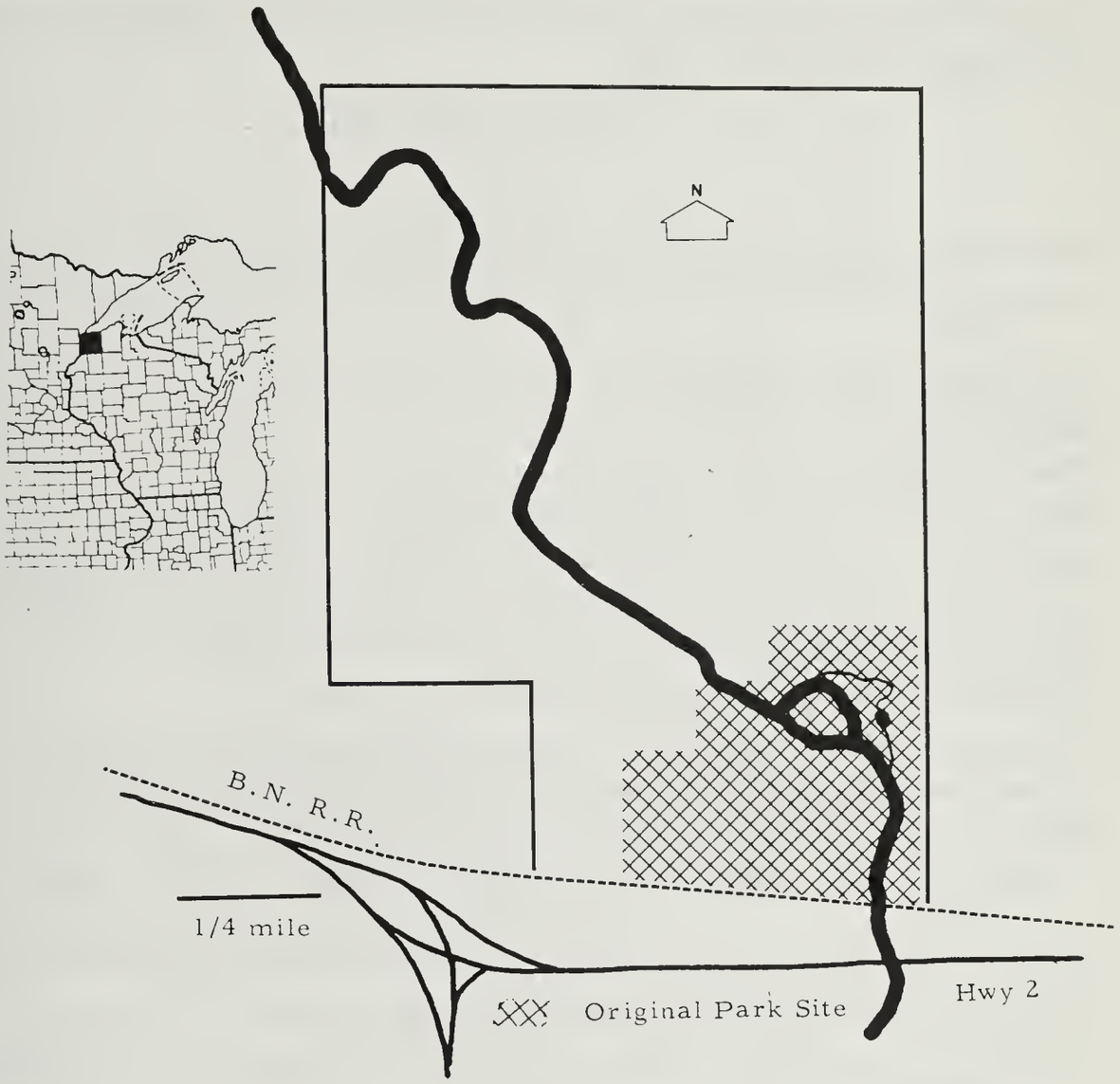

Fig. 1. Amnicon Falls State Park. (Inset shows location of Douglas County, Wisconsin.)

since this is the area of most habitat diversity. However, the other areas of the park were also collected.

The taxa collected are listed below, alphabetically, with a representative voucher collection and its habitat cited for each. All collections are in the herbarium of the University of Wisconsin–Superior. Duplicates of most collections are available in the collections of the authors. Schroeder's Musci collections are preceded by an "*M*" and his Hepaticae are preceded by an "*H*"; Koch's collections have no alphabetical prefix. Nomenclature follows that of Crum, Steere, and Anderson (1973). The species marked with an asterisk are thought to be new county records, based on the reports of Cheney and Evans (1946) and Forman (1967).

The authors wish to thank Drs. Lewis E. Anderson, Howard Crum, Harold Robinson, and Raymond Stotler for their generous assistance with the determination of difficult collections.

One taxon, *Dicranella schreberiana* var. *robusta* Schimp. ex Braithw., is apparently a new record for Wisconsin. The plant was located on a shaded igneous rock wall by the river and determined by Crum. The species, though

not this variety, has been reported from both the Upper and Lower Peninsulas of Michigan (Darlington, 1964).

LIST OF SPECIES

MOSSES

Amblystegium serpens (Hedw.) B. S. G.–On decaying stumps, wooded ravine, *6672.*

**Anomodon attenuatus* (Hedw.) Hueb.–Shaded soil on igneous rock wall, near falls, *M134.*

**A. rostratus* (Hedw.) Schimp.–Moist shaded rock wall, *M148.*

Atrichum undulatum (Hedw.) P. Beauv.–On soil along river, *M132.*

**Barbula unguiculata* Hedw.–Clay soil of roadside bank, *5289.*

Bartramia pomiformis Hedw.–Igneous rock ledges along river, *7362.*

**Brachythecium acuminatum* (Hedw.) Aust.–On base of small *Populus* tree, *6355.*

B. oxycladon (Brid.) Jaeg. & Sauerb.–On base of *Populus*, shaded and moist, *M416.*

**B. plumosum* (Hedw.) B. S. G.–On shaded rock in woods, *M413.*

B. rivulare B. S. G.–On wet soil on rocks along river, *M425.*

B. salebrosum (Web. & Mohr) B. S. G.–On rock along stream, woods, *M424.*

**Bryhnia novae-angliae* (Sull. & Lesq. ex Sull.) Grout–On moist soil, *M80.*

**Bryum caespiticium* Hedw.–Gravelly margin of ditch, *5322.*

B. pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb.–On wet, shaded rock wall, *M427.*

**B. uliginosum* (Brid.) B. S. G.–Wet, well shaded soil, vertical igneous rock walls, *M406.*

Callicladium haldanianum (Grev.) Crum–On rotting log, woods, *7366A.*

**Calliergonella cuspidata* (Hedw.) Loeske–Wet depression, marshy woods, with *Sphagnum, 7480B.*

Campylium hispidulum (Brid.) Mitt.–Decaying log, moist woods, *5320.*

Ceratodon purpureus (Hedw.) Brid.–Gravelly margin of ditches and roads, *5321.*

Climacium dendroides (Hedw.) Web. & Mohr–On moist, shaded soil along stream, *5317.*

Cratoneuron filicinum (Hedw.) Spruce–Wet soil along falls, partially shaded, *M149.*

**Dicranella schreberiana* var. *robusta* Schimp. ex Braithw.–Shaded igneous rock wall, *6365A.*

**Dicranella varia* (Hedw.) Schimp.–Soil on rock wall, *M93.*

Dicranum flagellare Hedw.–Rotting stump, woods, *M173.*

**D. montanum* Hedw.–On decaying wood, shaded woods, *7485.*

D. polysetum Sw.–Top of bank by river, pine stand, *M131.*

D. scoparium Hedw.–Shaded soil under fir tree, *6348.*

D. viride (Sull. & Lesq. ex Sull.) Lindb.–Grassy meadow, pipe line right-of-way, *7483A.*

**Distichium capillaceum* (Hedw.) B. S. G.–On rocky ledge, thin soil, shaded, *M154.*

**D. inclinatum* (Hedw.) B. S. G.–Shaded moist soil on vertical rock wall, *M141.*

**Drepanocladus aduncus* (Hedw.) Warnst., var. *polycarpus* (Bland. ex Voit) Roth–On ground, moist shaded ravine, *6961B.*

D. uncinatus (Hedw.) Warnst.–Rotting log, woods, *M140.*

Encalypta ciliata Hedw.–On shaded, moist soil on vertical igneous rock wall beside falls, *M415.*

**Eurhynchium pulchellum* (Hedw.) Jenn.–On soil in mixed woods along small stream, moist and shaded, *M414.*

Fissidens cristatus Wils. ex Mitt.–On soil next to water, *M88.*

**F. taxifolius* Hedw.–On soil, undercut bank by river, shaded and wet, *M152.*

**F. osmundoides* Hedw.–Shaded rocky ledge by stream, *7360.*

**F. viridulus* (Sw.) Wahlenb.–On soil at edge of water, *M92.*

Fontinalis hypnoides var. *duriaei* (Schimp.) Husn.–Small, rocky stream, *M423.*

Funaria hygrometrica Hedw.–Exposed soil along trail, *6363.*

**Grimmia apocarpa* Hedw.–On soil on rock by brook, sunny and dry, *M177.*

**Gymnostomum recurvirostrum* Hedw.–Thick mat on soil on rock wall, wet and shaded, *M170.*

**Haplocladium microphyllum* (Hedw.) Broth.–On decaying wood, woods, *M419.*

Hedwigia ciliata (Hedw.) P. Beauv.–On vertical rock wall by falls, *M142.*

**Helodium blandowii* (Web. & Mohr) Warnst.–On wet log, woods, *6678B.*

Hygroamblystegium tenax (Hedw.) Jenn.–On soil on rock wall, shaded and moist, *M418.*

Hylocomium splendens (Hedw.) B. S. G.–On shaded and moist soil in mixed woods, *M144.*

Hypnum fertile Sendt.–Rotting wood, woods, *6683.*

H. imponens Hedw.–On rotting stump, woods, *M145.*

**H. lindbergii* Mitt.–Wet area in woods, *6676.*

H. pallescens (Hedw.) P. Beauv.–On rock in woods, *6016.*

**Leptodictyon trichopodium* (Schultz) Warnst.–On shallow soil over rocks, shaded ravine, *5323.*

Mnium cuspidatum Hedw.–On soil in woods, *M178.*

M. medium B. S. G.–Shallow soil of rock along river, *5288.*

M. orthorrhynchum Brid.–On wet soil on rock along stream, *M329.*

M. punctatum Hedw.–On decaying log, ground, *7365.*

var. *elatum* Schimp.–At edge of small shaded pool, *M182.*

M. spinulosum B. S. G.–Wet soil along stream, shaded, *M179.*

Oncophorus wahlenbergii Brid.–On rotting log, woods, *7364.*

Orthotrichum obtusifolium Brid.–On dead *Populus* tree, *M166.*

O. sordidum Sull. & Lesq. ex Aust.–On *Populus* tree, *M422.*

O. speciosum Nees ex Sturm var. *elegans* (Schwaegr. ex. Hook. & Grev.) Warnst.–Clump on trunk of *Populus, 6679.*

**O. stellatum* Brid.–On trunk of *Populus, 6094A.*

Philonotis fontana (Hedw.) Brid.–On soil on igneous rock wall, shaded and moist, *M158.*

**Platygrium repens* (Brid.) B. S. G.–Base of *Populus*, by parking lot, *M176.*

Pleurozium schreberi (Brid.) Mitt.–Mat on soil, mixed woods, *M174.*

Pogonatum alpinum (Hedw.) Roehl.–Shallow soil on shaded rock, *M160.*

**Pohlia cruda* (Hedw.) Lindb.–At base of rock wall along brook, moist and shaded, *M432.*

P. nutans (Hedw.) Lindb.–On soil near base of pine tree, *5280.*

**P. wahlenbergii* (Web. & Mohr) Andr.–On ground in moist ravine, *6961A.*

Polytrichum commune Hedw.–Moist depression, hillside slope, *5282.*

P. juniperinum Hedw.–Shaded gravel bank, *5287.*

**P. piliferum* Hedw.–On shallow soil over rocks, exposed, *M138.*

Ptilium crista-castrensis (Hedw.) De Not.–On rotting log, woods, *M169.*

Pylaisiella polyantha (Hedw.) Grout–Decaying log, moist woods, *6104.*

forma *subdenticulata* (Schimp. ex B. S. G.) Crum–On base of *Populus* in woods, *5290.*

P. selwynii (Kindb.) Crum, Steere, & Anders.–On trunk of dead *Populus, 5701.*

Rhodobryum roseum (Hedw.) Limpr.–On soil on rock near falls, *M87.*

Rhytidiadelphus triquetrus (Hedw.) Warnst.–On shaded ground, woods, *M133.*

Saelania glaucescens (Hedw.) Bomanss. & Broth.–Face of shaded sandstone cut, ravine, *7486.*

**Sphagnum subsecundum* Nees ex Sturm–On wet log, depression in woods, *7480.*

Thuidium delicatulum (Hedw.) B. S. G.–Shaded and moist soil under herb cover, woods along stream, *M157.*

**Tortella tortuosa* (Hedw.) Limpr.–Moist, shaded soil on igneous wall, *M156.*

LIVERWORTS

Incidental to the collection of Mosses, the following Liverworts were found.

Chiloscyphus pallescens (Ehrh.) Dumort.–Decaying log, moist woods, *5320.*

Conocephalum conicum (L.) Dumort.–On shaded and wet clay on vertical rock wall, *H43.*

Lophozia barbata (Schmid.) Dumort.–On shaded rock near ground, *H39.*

Marchantia polymorpha L.–On wet, shaded soil and rocks, *H44.*

Plagiochila asplenoides (L.) Dumort.–On shaded soil on rock near river, *H40.*

Plectocolea crenuliformis (Aust.) Mitt.–Shaded and moist vertical rock wall, *H75.*

Porella platyphylloidea (Schwein.) Lind.–On shaded vertical rock ledge, *H41.*

Radula complanata (L.) Dumort–On shaded, moist rock wall, *H48.*

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COMPOSITION OF SOME OAK FORESTS IN SOUTHWESTERN MICHIGAN

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At the time of settlement, extensive areas in Michigan were covered with forests dominated by white pine (*Pinus strobus*). The southernmost stand of any size was located in Allegan County about 10 miles east of Lake Michigan (Kenoyer, 1934). Here, in an area of 12 by 16 miles, the pines grew in association with oaks on and around lake bed deposits laid down in some high-water stage during Wisconsin glaciation. These pines, like those of the larger stands to the north, were lumbered in the Nineteenth Century, and slash fires followed the lumbering. Timber cutting around Allegan probably began about 1835 when the first commercial sawmill was built (Johnson, 1880). Today xeric forests which have developed in approximately 100 years of secondary succession occupy much of the land. Five study areas chosen as representatives of the main physiognomic variations of such forest are described in this paper. Other vegetation types, such as sand barrens similar to those described by Curtis (1959), are present but were not investigated.

THE STUDY AREAS

The five areas, all within the 17,500-hectare Allegan State Game Area, were selected in the spring of 1966 (Table 1). Variation in the basic vegetation type, xeric oak or oak-pine forest, was examined and an effort was made to find large, relatively homogeneous stands where study areas of 8 or more acres would be surrounded by similar vegetation for at least 200 feet. Although derived from slightly different geological parent materials (Riggs, 1938), the soils on all the areas are sandy, well-drained, acid (*p*H, 4.4-6.4, tested colorimetrically), and low in fertility. Elevation varies in a narrow range from about 200 to 210 m above mean sea level. Charred pine stumps and rather frequent multiple-trunked oaks on all areas indicate that they have had similar histories of logging and fire.

METHODS

The rectangular study plots were established with steel tape and Brunton pocket transit. Wooden stakes were used to mark intersections of coordinates

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TABLE 1. Location, size, geological surface formation, and topography of the study areas.

Study area	Size (hectares)	Location	Geological surface formation	Topography
Small Oak	6.7	NW¼ Sec. 24, R 14 W, T 2 N	Valparaiso moraine	Slightly rolling
Small Pine	5.95	SW¼ Sec. 16, R 14 W, T 2 N	Glacial river delta	Flat
Large Pine	3.9	NE¼ Sec. 16, T 2 N, R 14 W	Glacial river delta	Rolling
Large Oak	7.4	NW¼ Sec. 30, R 14 W, T 2 N	Lake bed sand	Flat
Greenbrier	7.4	NW¼ Sec. 25, R 15 W, T 2 N	Lake bed sand	Flat

200 feet (60.96 m) or 100 feet (30.48 m) apart. These stakes were used as the sampling locations for studying tree composition by means of the point-centered quarter method (Cottam & Curtis, 1956). The method was modified to sample trees in two size categories, 1.5-4.99 inches in diameter at breast height (dbh) and 5 inches and greater dbh. The nearest tree in each of these categories was recorded for each quarter defined by cardinal points of the compass. Species, dbh, and distance from the point (measured with steel tape) were recorded. Thirty points, or 120 trees in each size category, were sampled on each plot. For the Large Oak and Greenbrier areas all of the 30 stakes at 200-foot intervals were used as sampling points. For the other areas, with some stakes at 100-foot intervals, all 200-foot stakes were used, and additional stakes were chosen using a stratified random sampling scheme to give the required number. Sampling extended from July 1966 to January 1969.

The two size categories used gave a fairly good separation of understory and canopy trees, the main exception being that some of the trees in the smaller category contributed to the canopy where it was low. In the following sections, "canopy" and "understory" are used to refer to the two size categories.

On the Large Oak area, a complete count of three woody species of low frequency was undertaken May 3-12, 1967. The species, black cherry (*Prunus serotina*), shadbush (*Amelanchier* sp.), and white pine, were readily countable because they were the only trees which had leaves at this time. The count was made by using the 20 squares produced in staking the area at 200-foot intervals as large quadrats; in a few sections, small pines were numerous enough that it was necessary to divide the quadrats into quarters. Counting was done by two observers making repeated traverses about 6 m apart across the quadrats. The count was virtually exact, although a few small seedlings of all species could have been missed. A complete count of canopy pines on the Large Pine Area was made in similar fashion in the summer of 1966.

Tree heights were calculated from measurements made in 1966-67 using a sighting level and steel tape. The number of measurements in each area was few, made on trees judged representative of the class being considered.

An attempt was made on four areas to estimate the density of the remaining pine stumps. On the Small Pine Area, a complete count was attempted in the early spring of 1967, using the 32 200 × 100 foot rectangles produced in staking the area as large quadrats. As a check on the reliability of the count, 15 of the quadrats were reexamined in 1972. The two counts were virtually identical (162 vs. 157 trees, or a 3% difference). On the Large Oak, Small Oak, and Greenbrier areas, density was estimated by the closest individual method (Cottam & Curtis, 1956). The sampling was done between 1969 and 1972. The stakes (26-30) in each area were used as sampling points.

Light intensities, as reported in this paper, were taken about 4½ feet off the ground, between 11:30 AM and 1:30 PM EST, on clear days. The instrument used was a Weston sunlight illumination meter with a Viscor filter. The sensing element was directed vertically while the observer faced the sun. Sample sizes were 5 for each area in May 1966, 10 for each area in August 1966, and 18 for each area on the two dates in 1968. Points for sampling were haphazardly chosen in 1966 and were systematically chosen at 100-foot intervals in 1968. For comparative purposes, light intensities were also taken in a beech-maple forest in Kalamazoo County, about 30 miles southeast of the Allegan areas in May and August, 1966.

The general comments on smaller woody plants and herbaceous vegetation are based on non-quantitative observation and on sampling with milacre quadrats as reported in Hodgson (1969) and Wenger (1970).

Plant names follow Gleason (1952).

SMALL OAK AREA (Fig. 1)

The distinctive feature of this area (Table 2) was the large number of trees in the 5-10 inch dbh class (180 per acre). Larger trees were moderately dense, so that the total density of canopy trees was the highest here of any of the areas (Table 3). White oaks (*Quercus alba*) dominated among the smaller canopy trees, but almost 80 percent of the trees 10 inches dbh and above were black oak (*Q. velutina*). In the understory, white oak predominated, as it did on all five areas (Table 4). Dogwoods (*Cornus florida*) were numerous in the understory here (86 per acre). Only two other species (black oak and white pine) were recorded in the understory sample, the fewest of any of the areas. Pines were scarce both in the understory and the canopy although the only canopy pine was the largest tree on the area, 22.6 inches dbh. Canopy height was mostly 60-75 feet.

SMALL PINE AREA (Fig. 2)

Most of the small white pines, which formed an understory layer 10-22 feet tall throughout this area, were interplanted in 1938, although there has probably been some natural reproduction by the single large pine on the area and others on adjoining land. The canopy on this area was variable in height,

TABLE 2. Number of trees per acre in four size classes on five oak forest study areas in Allegan County, Michigan.

Species	Size classes (inches dbh) 1.5-4.99	5.0-9.99	10.0-14.99	15.0 and larger
	Small Oak Area			
Pinus strobus	2	–	–	2
Quercus alba	254	133	6	2
Q. velutina	12	47	34	2
Cornus florida	86	–	–	–
	Small Pine Area			
Pinus strobus	263	1	–	–
Populus grandidentata	18	6	–	–
Q. alba	394	71	14	6
Q. velutina	12	17	2	6
Prunus serotina	–	2	–	–
Acer rubrum	18	2	–	–
C. florida	12	–	–	–
	Large Pine Area			
Pinus strobus	3	–	6	3
Populus grandidentata	–	8	–	–
Q. alba	307	82	8	–
Q. velutina	56	63	16	1
Prunus serotina	42	2	–	–
C. florida	11	–	–	–
	Large Oak Area			
Pinus strobus	12	–	–	–
Q. alba	212	22	6	5
Q. velutina	21	24	49	15
Sassafras albidum	2	–	–	–
Prunus serotina	2	–	–	–
A. rubrum	5	–	–	–
C. florida	28	–	–	–
	Greenbrier Area			
Populus grandidentata	6	11	–	–
Q. alba	284	28	2	1
Q. velutina	30	18	24	12
S. albidum	6	–	–	–
Prunus serotina	6	1	–	–
A. rubrum	15	2	–	–
Nyssa sylvatica	9	–	–	–
C. florida	3	–	–	–

about 35-75 feet, and several small openings occurred. White oak dominated the canopy in the whole range of dbh classes from 5-15 inches, but among the largest trees, white and black oak were about equally numerous. This was the only area where black oak did not definitely dominate the larger size classes. The larger white oaks, although not extremely spreading, seemed more open-grown here than on other areas. The largest tree observed was a white

Fig. 1. Small Oak Area. A large black oak is seen in the left foreground. Most of the rest of the trees are understory or small canopy white oaks. Trunks of the larger trees in all study areas are moss- and lichen-covered. All photographs taken April 26, 1969, by R. Brewer.

TABLE 3. Characteristics of the canopy trees of the Small Oak area based on the point-centered quarter method. (Average distance was 13.9 feet; density was 225 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Pinus strobus	22.6	5.6	.03	1.8	0.8	6.0	8.6
Quercus alba	6.5	35.4	0.9	54.2	62.5	41.2	157.9
Q. velutina	9.6	44.6	.73	43.9	36.7	52.8	133.4

oak 27.3 inches dbh. Canopy composition was most diverse on this area, 6 species being encountered in the point-centered quarter sampling (Table 5). Because of the large number of small pines, understory tree density (Table 6) was far higher here than on the other tracts. Even when the pines are ignored, density here was slightly higher than on the other tracts because small white oaks were denser here than elsewhere (Table 2). Dogwoods were scarcer here than on any other area except the Greenbrier area.

Fig. 2. Small Pine Area, from outside the forest to the north.

TABLE 4. Characteristics of the understory trees of the Small Oak area based on the point-centered quarter method. (Average distance was 11.1 feet; density was 354 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Pinus strobus	2.2	.05	.03	1.7	0.8	0.4	2.9
Quercus alba	3.5	18.3	1.0	56.8	71.7	85.8	214.3
Q. velutina	4.4	1.1	.13	7.4	3.3	5.3	16.0
Cornus florida	1.9	1.8	0.6	34.1	24.2	8.5	66.8

LARGE PINE AREA (Fig. 3)

This was the only area with substantial numbers of canopy pines (Table 7). A direct count showed 50 canopy pines in 1966 (one died during the winter of 1966-67), or 5.2 per acre. This is in reasonable agreement with the 9 per acre estimated by the point-centered quarter method (Table 2). The canopy pines were distributed diagonally across the plot, being scarcest on the southeast and northwest corners. Pines in the size classes from 1.5 to 10 inches dbh were scarce, but smaller trees were fairly numerous and appeared to be making good growth. The large pines were 60-70 feet tall; the tallest

Fig. 3. Large Pine Area. The rolling topography is evident. A white pine stump is noticeable in the foreground.

TABLE 5. Characteristics of the canopy trees of the Small Pine area based on the point-centered quarter method. (Average distance was 18.4 feet; density was 129 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Pinus strobus	6.0	0.2	.03	1.6	0.8	0.3	2.7
Populus grandidentata	6.2	1.3	0.1	5.3	4.2	1.7	11.2
Quercus alba	8.1	37.3	1.0	53.5	71.7	57.2	182.4
Q. velutina	11.3	25.9	0.6	32.1	20.0	39.3	91.4
Prunus serotina	6.6	0.5	.07	3.7	1.7	0.8	6.2
Acer rubrum	5.6	0.3	.07	3.7	1.7	0.6	6.0

oaks were 60-65 feet tall, but much of the canopy was composed of smaller trees of 50-60 feet. This area resembled the Small Pine area in having a dense understory tree layer (Table 8) and resembled the Small Oak area in having a high density of trees 5-10 inches dbh. It differed from the Small Oak area in that white and black oak were about equally well represented in this size

TABLE 6. Characteristics of the understory trees of the Small Pine area based on the point-centered quarter method. (Average distance was 7.8 feet; density was 716 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Pinus strobus	2.5	9.9	0.7	36.1	36.7	26.6	99.4
Populus grandidentata	3.6	1.3	0.1	5.2	2.5	3.5	11.2
Quercus alba	3.2	23.8	0.9	46.4	55.0	63.9	165.3
Q. velutina	4.6	1.4	.07	3.6	1.6	3.6	8.8
Acer rubrum	2.4	0.6	0.1	5.2	2.5	1.6	9.3
Cornus florida	2.1	0.3	.07	3.6	1.6	0.8	6.0

TABLE 7. Characteristics of the canopy trees of the Large Pine area based on the point-centered quarter method. (Average distance was 15.2 feet; density was 189 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Pinus strobus	13.9	9.9	0.1	5.6	5.0	13.6	24.2
Populus grandidentata	8.6	3.2	.07	3.9	4.2	4.1	12.2
Quercus alba	6.6	23.1	0.8	44.4	47.5	32.1	124.0
Q. velutina	7.8	29.9	0.8	44.4	42.5	49.8	136.7
Prunus serotina	5.7	0.4	.03	1.7	0.8	0.4	2.9

TABLE 8. Characteristics of the understory trees of the Large Pine area based on the point-centered quarter method. (Average distance was 10.2 feet; density was 419 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Pinus strobus	3.3	0.4	.03	1.7	0.8	0.8	3.3
Quercus alba	3.1	33.8	1.0	56.9	73.3	74.7	204.9
Q. velutina	3.6	8.1	0.4	22.7	13.3	16.5	62.5
Prunus serotina	1.8	2.7	2.3	13.1	10.0	6.0	29.1
Cornus florida	2.8	0.9	0.1	5.7	2.5	1.9	10.1

class. As on most of the areas, black oak predominated in the size classes above 10 inches. The largest tree tallied was a white pine of 18.3 inches dbh.

LARGE OAK AREA (Fig. 4)

Total tree density on the Large Oak area was lowest of the five areas (405 trees per acre) and so was understory tree density (283 trees per acre). The canopy trees were large. About 19 per cent of the canopy trees were above 10 inches dbh compared with percentages of 3-8 for the other areas. The height of the canopy trees varied from 50-105 feet. Basal area for the canopy trees was nearly 100 square feet per acre (Table 9), the highest of any

Fig. 4. Large Oak Area. The larger trees and greater spacing is evident in comparison with Figure 1.

TABLE 9. Characteristics of the canopy trees of the Large Oak area based on the point-centered quarter method. (Average distance was 18.9 feet; density was 122 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Quercus alba	9.5	20.7	0.7	43.8	27.5	20.8	92.1
Q. velutina	11.9	77.3	0.9	56.2	72.5	79.2	207.9

area. The canopy was dominated by black oaks, although white oaks were about equally common in the 5-10 inch dbh class. Three canopy black oaks (one just off the study area) were snapped off 5-6 feet up in a windstorm between June 10 and 15, 1969. These trees were hollow.

Dogwoods about 17 feet tall were prominent in the understory (Table 10), although less common than on the Small Oak area. The dogwoods on all areas tended to occur as clones of one to a few stems of 1-2 inches dbh surrounded by a roughly circular patch of many low stems arising as root sprouts. Sixteen such clones in which at least one stem was 1.5 inches dbh or larger were randomly selected for measurement on the Lake Oak area. The mean dimensions were 15 feet (north-south axis) by 13 feet (east-west).

TABLE 10. Characteristics of the understory trees of the Large Oak area based on the point-centered quarter method. (Average distance was 12.4 feet; density was 283 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Pinus strobus	2.7	0.5	0.1	6.3	4.2	4.1	14.6
Quercus alba	2.6	8.8	.96	60.4	75.0	72.9	208.3
Q. velutina	2.9	1.1	0.1	6.3	7.5	9.2	23.0
Sassafras albidum	1.6	.01	.03	1.9	0.8	0.3	3.0
Prunus serotina	1.9	.02	.03	1.9	0.8	0.4	3.1
Acer rubrum	2.9	0.6	.07	4.4	1.7	4.6	10.7
Cornus florida	2.5	0.9	0.3	18.9	10.0	8.6	37.5

The understory was relatively diverse, a total of seven species occurring in the sample. One of the three understory species for which complete counts were made was not recorded in the point-centered quarter sampling. This was shadbush which had an actual density of about one plant per 2.5 acres in the 1.5-4.99-inch category. This species also occurred at low densities on the other four areas. The total count for black cherry (17 trees) in this size class was similar to the density obtained by the point-centered quarter method (about one plant per acre). The results of the two methods differed considerably for white pine, however. The actual density of white pines in the 1.5-4.99-inch dbh category was only two trees per acre (30 on the 18.4 acres) compared with the estimated 12. This error may be related to the distribution of pine, which was strongly non-random, being concentrated on the western side of the tract toward the road. Three white pines of canopy size occurred on the tract, although none was encountered in the point-centered quarter sampling. The largest was just under 14 inches dbh. Many of the small pines were probably the result of natural seeding from these larger pines and others across the road; some, however, were probably planted. The largest tree of any species included in the sampling was a white oak 22.4 inches dbh.

GREENBRIER AREA (Fig. 5)

The Greenbrier area had a less homogeneous canopy than the other four areas, having been selected on the basis of its dense, though patchy stratum of greenbrier (*Smilax rotundifolia*). The area could be roughly divided into three canopy subtypes: an area of large trees 71-84 feet tall and having a general resemblance to the Large Oak area, areas of denser oaks 29-49 feet tall, and a discontinuous strip of open patches running east-west near the center of the plot. Occasional large oaks and patches of large-toothed aspen (*Populus grandidentata*) grew in and around these openings. The area had the lowest density and basal area for canopy trees and the lowest total basal area (Tables 11, 12). The open areas were the main reason for this. The largest tree included in the sampling was a black oak 28.6 inches in diameter. Aspens were more common on this area than elsewhere; considerable mortality was evident among them during the four years of observation on the tract. There were no canopy or understory pines. Diversity among the non-canopy species was greater here than elsewhere, eight species being recorded in the samples. Pepperidge (*Nyssa sylvatica*) appeared here but was absent from the other areas. Flowering dogwood was much scarcer here than elsewhere.

Fig. 5. Greenbrier Area. A view near the center of the tract showing a large white oak surrounded by openings. The dense vine growth is greenbrier. An area of dense, low white oaks is visible in the background.

TABLE 11. Characteristics of the canopy trees of the Greenbrier area based on the point-centered quarter method. (Average distance was 21.1 feet; density was 98 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Populus grandidentata	6.3	2.7	0.4	19.9	10.8	4.3	35.0
Quercus alba	7.1	7.3	0.6	29.8	31.7	12.5	74.0
Q. velutina	11.5	45.8	0.9	44.8	55.0	81.8	181.6
Prunus serotina	5.7	0.2	.04	1.9	0.8	0.2	2.9
Acer rubrum	6.1	0.4	.07	3.5	1.7	1.2	6.4

TABLE 12. Characteristics of the understory trees of the Greenbrier area based on the point-centered quarter method. (Average distance was 11.2 feet; density was 359 trees per acre.)

Species	Mean dbh (inches)	Basal area per acre (sq. ft.)	Frequency	Relative frequency	Relative density	Relative dominance	Importance value
Populus grandidentata	3.4	0.1	.07	4.1	1.7	0.8	6.6
Quercus alba	2.9	15.2	0.96	55.8	79.2	84.7	219.7
Q. velutina	2.8	1.3	0.3	17.4	8.3	6.9	32.6
Sassafras albidum	1.8	0.1	.07	4.1	1.7	0.6	6.4
Prunus serotina	2.9	0.3	.04	2.3	1.7	1.5	5.5
Acer rubrum	2.1	0.1	0.2	11.6	4.2	1.9	17.7
Nyssa sylvatica	2.7	0.4	.04	2.3	2.5	3.2	8.0
Cornus florida	1.7	.05	.04	2.3	0.8	0.2	3.3

HERBACEOUS AND SMALLER WOODY VEGETATION

Because these portions of the vegetation have been less thoroughly studied than the larger woody plants, only a brief discussion touching on some of the more obvious features will be given. By far the most common woody plants, based on stem counts (Hodgson, 1969; Wenger, 1970), were flowering dogwood and sassafras (*Sassafras albidum*). The high counts for dogwood are the result of its root-sprouting tendency already noted. Dense clones of low stems, in which little else grew, were formed. Sassafras, however, was spread throughout most of the forests at densities of around 8000 plants per acre. It tended to occur as small clumps of dead stems and new root sprouts. Very few stems reached 1.5 inches dbh before dying. Black cherry showed a somewhat similar pattern, but was scarcer in the size classes below 1.5 inches dbh and slightly more common in the understory tree class. On the Large Oak area, the complete count of the 18.4 acres showed 46 cherries 2 feet high or smaller and 105 between 2 feet high and 1.49 inches dbh.

There was no obvious difference in numbers of black and white oaks in the below-1.5 inch dbh class; the number of stems of each was around 1700-2000 per acre. There was some indication that black oak suffered greater attrition in the size range between 2 feet tall and 1.5 inches dbh, and in the understory tree category white oak outnumbered black oak from 6 to 30 to 1 (Table 2).

Small numbers of small white pines occurred on all the study area. The numbers ran from only two for the whole 18.4 acres of the Greenbrier area to modest densities of perhaps 20 per acre on the Small and Large Oak areas to a rather high density on the Large Pine area. The Small Pine area is difficult to analyze because of the large number of planted pines. On the Large Oak area, the complete count indicated 39 white pines 2 feet high or smaller and 270 between 2 feet high and 1.49 inches dbh. Densities on the Large Pine area were considerably higher, probably in the range of one thousand to a few thousand per acre.

Seven arborescent species not mentioned above or in previous sections were observed. Witch hazel (*Hamamelis virginiana*) occurred as rare patches on most areas. Choke cherry (*Prunus virginiana*) was present in small numbers. One good-sized hickory (*Carya ?ovalis*, 17 inches dbh) and several smaller ones grew on the Large Pine area, as did a patch of blue-beech (*Carpinus caroliniana*). One clump of small stems of basswood (*Tilia americana*) was found on the Large Pine and the Small Oak areas. A few canopy-size pin oaks (*Quercus palustris*) were present on the Greenbrier area. Red maple was emtremely scarce in the size classes below 1.5 inches dbh, suggesting that few seed trees were available near any of the areas and that the occasional understory tree found on most of the areas had resulted from rare long distance transport. One to a few small beeches (*Fagus grandifolia*) less than 3 feet tall, have been noticed on all the areas except the Small Pine. Seed sources of beech exist on more mesic sites in the region, such as around Ely Lake and the Kalamazoo River.

The herb and shrub flora was rather poor in numbers of species. As with the trees, species composition on the five areas was similar, the major differences being in abundance rather than presence or absence of species. The areas which deviated most strongly from this pattern were the Large Pine area which had a more diverse herb layer than the other areas and the Greenbrier area which seemingly did lack some of the species occurring elsewhere and had a few not occurring elsewhere.

The most generally distributed shrubs were dryland blueberry (*Vaccinium vacillans*), a rose (*Rosa* sp.), and New Jersey tea (*Ceanothus americanus*). The only tall shrub that occurred on all areas (possibly excepting the Greenbrier area) was maple-leaved viburnum (*Viburnum acerifolium*). Among the low shrubs, wintergreen (*Gaultheria procumbens*) and pipsissewa (*Chimaphila umbellata*) were fairly widely distributed, the former common on the Large Oak and Greenbrier areas, the latter not common on any area. A low *Rubus* was present on all areas. Sweet-fern (*Comptonia peregrina*) was present only in openings on the Greenbrier area. Greenbrier (*Smilax rotundi-*

folia) was very common on the Greenbrier area where it formed dense patches over much of the area, but it was present at a low frequency on most or all of the other areas. Huckleberry (*Gaylussacia baccata*) was more common on the Large Oak area than elsewhere, and a tall blueberry (possibly *Vaccinium corymbosum*) occurred on the Greenbrier area. Various other species were noted in small numbers on only one or two areas. these included hazelnut (*Corylus americana*), a grape (*Vitis* sp.), and hawthorn (*Crataegus* sp.).

Approximately 11 species of herbs were identified on the Greenbrier area, 19-22 on the Small Oak, Small Pine, and Large Oak areas, and 29 on the Large Pine area. These numbers could doubtless be enlarged by systematic collection and they are influenced by the intensity of observation on the various areas (more time was spent on the Large Oak than on other areas), but the general trend in diversity shown is certainly valid.

The herbaceous portion of the field layer of the forests was sparse almost everywhere. About the only herbaceous species that occurred in numbers on all areas were bracken fern (*Pteridium aquilinum*), a sedge (*Carex pensylvanica*), black oat grass (*Stipa avenacea*), and three species of beggar's-ticks (*Desmodium paniculatum, D. rotundifolia,* and *D. nudiflorum*). Other fairly widely occurring herbs were lousewort (*Pedicularis canadensis*), lupine (*Lupinus perennis*), bastard toadflax (*Comandra umbellata*), a cinquefoil (*Potentilla* sp.), a milkweed (*Asclepias exaltata*), a blue violet (*Viola fimbriatula*), two goldenrods (one *Solidago caesia*), false Solomon's seal (*Smilacina* sp.), Indian pipe (*Monotropa uniflora*), a sunflower (*Helianthus divaricatus*), a shinleaf (*Pyrola rotundifolia*), and cow-wheat (*Melampyrum lineare*). Some species that were present on the Large Pine area but rare or absent on most of the other areas were columbine (*Aquilegia canadensis*), may-apple (*Podophyllum peltatum*), hepatica (*Hepatica americana*), partridge berry (*Mitchella repens*) and Canada mayflower (*Maianthemum canadense*). Moccasin flower (*Cypripedium acaule*) was found only on the Greenbrier area.

ORIGINAL FORESTS

An attempt was made to reconstruct features of the original forests by studying the remaining pine stumps. On the 14.7-acre Small Pine area 317 stumps were counted for a density of about 19 per acre. Similar densities were obtained (using the closest individual method) for the Large and Small Oak areas (24 and 22 trees per acre, respectively). Density on the Greenbrier area was much lower, about 7 trees per acre.

On the Small Pine area stumps were measured about 1.5 feet above the ground. The mean diameter was about 15 inches and the largest about 40. Some two-thirds of the stumps were in the range 8-20 inches. Translated to dbh figures (using correction factors based on living white pines in the area), the range is 7-18 inches.

Spacing of the pine stumps on the Small Pine area was studied by comparing mean number of stumps per 200 × 100 foot quadrat with the variance of the mean. The variance: mean ratio (Greig-Smith, 1964, pp. 61-63) was calculated as 2.29. The difference between this value and unity compared

with the standard error of the difference gives a t value of 5.078, indicating a significant deviation from random spacing. Aggregation is indicated.

A second approach to determining structure of the original forests was use of original land survey data (for a discussion of the ecological use of such data see Bourdo, 1956). Table 13 gives information from the survey notes thought to be relevant to the five study areas. Some subjectivity was involved in deciding what points to include under a particular area. The general rule was to include the nearest section corner or quarter-section point plus any others if within one-half mile of the study area. Also any trees intercepting

TABLE 13. Vegetation near the five study areas based on notes of the original land survey (1831).

Tree	Diameter (inches)	Distance (feet)	Surveyor's Comments
		Small Oak Area	
Pine	10	42	Same as last mile, pine, oak.
Pine	12	56	
Pine	30	–	
Pine	12	–	
		Small Pine Area	
Beech	12	10	Undergrowth oak and
Pine	26	19	sassafras, very thick.
White Oak	–	–	
Pine	20	–	
Pine	24	18	
Pine	24	7	
Pine	15	10	
Beech	10	14.5	
		Large Pine Area	
White Oak	10	13	Land same as last mile (i.e.,
White Oak	18	30	land rolling, 2nd rate, beech,
Hickory	14	39	pine, oak).
Pine	30	16.5	
Pine	14	–	
		Large Oak Area	
Pine	7	15	Land gently rolling and 3rd
Pine	10	8	rate. Pine and oak. Under-
White Oak	24	44	growth oak and greenbrier.
White Oak	10	13	
Pine	20	7	
Pine	8	34	
White Oak	12	–	
		Greenbrier Area	
Jack Oak	8	13	Land level, 2nd rate. Birch,
Maple	10	15	pine, oak.
Pine	10	14	
Maple	12	86	

the surveyor's line (these are trees for which no distance is given in Table 13) within one-half mile of the study area were included; however, trees or points on land physiographically dissimilar to the study areas were omitted even if close by.

The data confirm that the area was dominated by white pine in 1831 (when the region was surveyed) and suggest that white oak was second in importance (Table 13).

The estimates of stump densities presumably are underestimates of the original pine densities because of the loss of some stumps (especially smaller ones) through decay. As a comparison of original pine densities we used the closest pine at each section corner or quarter-section included in Table 13 as a closest individual datum. With a sample size of 8, a density of about 27 pines per acre was calculated. This is reassuringly close to the 19-24 trees per acre obtained by stump counts for three of the areas.

One conclusion to be drawn from these studies is that the Large Pine area of the present study, with its density of 5 canopy pines per acre, cannot be taken as similar to the original pine forests except possibly where pines were sparsest. Of pine-dominated forests described in the literature we have seen, the original Allegan forests seem closest to the old-growth forest at Interlochen State Park, 150 miles further north in Michigan, described by Kittredge and Chittenden (1929) and Waterman (1919).

FUTURE SUCCESSIONAL TRENDS

We see nothing in the data given here to suggest that these areas will not be 20 or 40 years hence what they are now, xeric oak forests. Some directions of change seem indicated, however. The largest black oaks are past their prime and susceptible to wind damage; deaths from this and other causes should allow increasing dominance by white oak. Only two species presently growing in the areas seem to have the potentiality of replacing white oak. These are red maple, which is scarce, and beech, which is very scarce. Larson (1953) has described oak forests in Wisconsin dominated by red oak but also containing black and white oak in which red maple appeared to be spreading out from seed trees and slowly taking over the area. He suggested that a red oak-red maple forest may be a transitional stage between the oak forests and the maple-basswood climax forest of that area. The rather large numbers of red maple in the Interlochen forest described by Kittredge and Chittenden (1929) suggests that a similar trend in the Allegan forests may not be far-fetched, even though the usual role of red maple in southwestern Michigan is in swamp forests. If such a process is to occur in the Allegan forests, it will be deferred until the present scattered red maples reach flowering size.

It is interesting to speculate on the future role of white pine in these forests. The species has an intriguing size distribution, with some large trees, few or no middle-sized trees, and on most areas a fair number of small trees. This pattern is explainable in at least three ways: (1) poor success of trees of intermediate size (presumably this accounts for the similar pattern shown by the Interlochen forest); (2) the recent arrival of the pines (which survived

lumbering and fire) at seed-producing age; and (3) a recently terminated period of conditions unfavorable to white pine reproduction or growth.

The modest growth of the planted pines on the Small Pine area in the last 30 years is consistent with any of the possibilities. The intermediate shade tolerance of white pine may suggest that pine is unlikely to increase in the canopy of these forests. Light intensities of 10-13 per cent full sunlight are said to result in poor survival of small trees (Fowells, 1965) and, once full canopy is achieved in the Allegan oak forests, light intensities (Table 14) are well below this level (except for sunflecks and occasional openings). The late leafing of the oak forests may, however, allow greater persistence and even success of white pines than would be expected simply from a knowledge of mid-summer light levels; Essentially winter canopy conditions persist until the end of May and the canopy is not complete until well into June in most years (Table 14). Closing of the canopy occurs much earlier in forests where maples are important constituents.

TABLE 14. Median light intensities (in percent of full sunlight) in the Allegan Forest tracts. Ranges (in parentheses) are given for the Large Oak Area.

	Date			
Study area	May 16-23 1966	May 18 1968	June 7 1968	August 17-19 1966
Small Oak	54	–	–	4.4
Small Pine	59	–	–	6.1
Large Pine	72	–	–	2.3
Large Oak	73 (60-94)	65 (10-97)	14 (7-47)	3.0 (1.5-14.8)
Greenbrier	78	–	–	1.5
Beech-Maple Forest (Kalamazoo Co.)	8	–	–	1.1

SUMMARY

Five areas of oak forest in a region of Allegan County, Michigan, dominated by white pine before lumbering and fires in the Nineteenth Century, were studied. The areas were on sterile, sandy soil, on and around a glacial lake bed. In general, black oak was predominant among the larger canopy trees and white oak among the smaller canopy and understory trees. White pines were important in the canopy on only one area, the Large Pine. Understory white pine larger than 1.5 inches dbh were scarce on all areas except the Small Pine where they had been interplanted in 1938. Smaller pines occurred at densities varying from one per ten acres (Greenbrier) to a thousand or more per acre (Large Pine). Flowering dogwood was common as a small tree on the Small and Large Oak areas but was all but absent from the Greenbrier area. Overall, densities of canopy trees ran from 122 per acre (Large Oak) to 225 per acre (Small Oak). (The Greenbrier area had a density of only 98 trees per acre because of openings.) Understory trees (1.5-4.99 inches dbh) had densities from 283 (Large Oak) to 716 (Small Pine).

Vaccinium vacillans, Rosa sp., *Ceanothus americanus,* and *Viburnum acerifolium* were widely distributed shrubs; *Smilax rotundifolia* occurred in dense patches on the

Greenbrier area. *Pteridium aquilinum, Carex pensylvanica, Stipa avenacea,* and three species of *Desmodium* were common herbs; however, herb density was low.

Based on studies of the remaining pine stumps and information from the original land survey (1831), the primeval forests had pines at a density of about 30 trees per acre; white oak was second in importance. The forests may have resembled the old-growth stand at Interlochen studied by Kittredge and Chittenden (1929).

Future changes in composition of the forests may be an increased dominance by white oak and, later, increased importance of red maple. The future role of white pine is debatable. The late leafing of oaks possibly allows better growth of the pines than might be supposed on the basis of mid-summer light conditions.

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CLAVARIADELPHUS JUNCEUS IN CENTRAL MICHIGAN

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Fall of 1972 appears to have been an exceptionally good year for the growth of *Clavariadelphus junceus* (Fr.) Corner in central Michigan. The pale yellow fruit-bodies of *C. junceus* (resembling chlorotic grass seedlings) were 2-6 cm high, filiform-acute, rigid, and seldom branched. This description agrees with that provided by Corner (1950). Identification has been verified by Dr. Ronald Petersen of the University of Tennessee (personal communication). This fungus was observed in a location commonly known as "the bird sanctuary" in section 32, T14N, R5W (Deerfield Township), Isabella County, Michigan. Specimens of this fungus have been placed in the Central Michigan University fungal collection.

The weather had been warm and moist and in late October *Clavariadelphus junceus* literally covered the hardwood forest floor. It grew in such profusion that at first glance it appeared as if the ground had been sown to lawn grass seed. Closer examination revealed that the pale yellow fungus was attached to leaves of *Acer, Quercus,* and *Betula* by filamentous rhizomorphs (Fig. 1).

Fig. 1. Filamentous attachment of *Clavariadelphus junceus* (at right) to a *Quercus* leaf.

According to the literature this fungus is a relatively cosmopolitan species but it is seldom, if ever, reported. In a literature search covering the past 10 years I was unable to find any reference to finding *Clavariadelphus junceus* in the field in Michigan or elsewhere. Most certainly it must be quite common in Michigan as evidenced by the luxuriant quantities observed this past fall. It may be that since *C. junceus* is small in stature and light in color it is overlooked, even by mycologists.

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Publications of Interest

THE PLANTS OF SOUTHERN NEW JERSEY. By Witmer Stone. Quarterman Publications, Inc., Boston. 1973. pp. [12] + 25-828 + 129 pl. $25.00. Here is a welcome reprint of a 1911 classic, only slightly altered (original folded colored map reduced to a 1-page black and white; photos of Stone and a favorite spot in the Pine Barrens added; a new and abbreviated title page; a new 4-page foreword by Elizabeth Woodford; and the plates now printed on both sides). The work consists largely of a complete annotated flora for the vascular plants, with keys. The introduction of nearly 100 pages is mainly phytogeographic. The nomenclature and other details are as obsolete in many instances as would be expected in a work over 60 years old, but the text is more readable and informative than the average flora. The plates and the text have both reproduced very well. The volume is available postpaid directly from the shipping facility of the publisher at 5 South Union St., Lawrence, Massachusetts 01802. (The price, incidentally, is exactly the same as that asked for a newly bound copy of the original edition in a dealer's catalog received within a few days after this reprint.) Students of the Pine Barrens should now be well supplied with literature, thanks to two 1970 publications: The Dover paperback reprint (at $3.50) of John W. Harshberger's *The Vegetation of the New Jersey Pine-Barrens* (1916) and Jack McCormick's "The Pine Barrens: A Preliminary Ecological Inventory" (New Jersey State Museum Report 2. $2.75).

SOME LICHENS OF ELGIN COUNTY, ONTARIO. By William G. Stewart (6 Yarwood St., St. Thomas, Ontario). A list of over 70 taxa, originally appearing on pp. 6-10 of *The Cardinal*, No. 74 (November 1972), the mimeographed bulletin of the McIlwraith Field Naturalists of London Ontario. Determinations were made by specialists (Crum, Thomson, Brodo).

INDEX TO VOLUMES 10-12

With the exceptions here noted, this index intends to be complete for the three volumes, including all scientific names of genera and species, titles (by important words), authors, and subjects. NOT indexed, in general, are the following: news items, editorial notes, items in literature lists or summaries, common names or names of taxa higher than genus or lower than species except when there is a major discussion or use of them, names in identification keys. Reviews are ordinarily listed only (by title) under "reviews"—not under the author or title of the works reviewed nor under the reviewer's name. "Publications of Interest" are not indexed although that general heading is. Pictures are indexed under their explanations (whether on the same page, a facing page, or in the case of cover pictures, the rear cover). If an article has three or more joint authors, the others are cross-referenced to the senior author without repetition of title; if there are only two authors, both are fully indexed with title. Names of persons not followed by a title or cross-reference indicate information about the person. Most other references to persons are not indexed.

Species mentioned in passing or in habitat descriptions are generally not indexed, especially if the point does not appear to be providing ecological, taxonomic, or distributional information about those species. If a paper includes a list of species in an area, additional mention of the species in tables or descriptions of the area are usually not additionally indexed. In order to reduce both the labor and the space required for this index, we have also omitted the following:

(1) The catalog of over 1100 species of vascular plants in Rock County, Wisconsin (10: 159-191);

(2) The nearly 500 species in the table of flowering dates for the Matthaei Botanical Gardens (11: 90-114);

(3) Names (except new ones) of corticolous pyrenolichens already indexed in Vol. 12, p. 68.

All new names and new combinations are indexed and appear in bold face type.

The attention of phytogeographers is called to the special entry "Distribution Maps," where all species are listed for which partial or complete maps have been published.

Abietinella abietina, 10: 5
Acer rubrum, 11: 39-41; 12: 169, 220-228
Acetabula, 11: 155
  acetabulum, 11: 159
  leucomelas, 11: 158
Adder's-Tongue, the Southeastern, Ophioglossum vulgatum var. pycnostichum, Found for the First Time in Michigan, 10: 67-74
Additional Nomenclatural and Other Notes on Michigan Monocots and Gymnosperms, 11: 26-36
Adiantum pedatum, 10: 196
Agaricus diminutivus, 10: 129
Agrimonia parviflora, 10: 191
Agrocybe
  acericola, 10: 129
  dura, 10: 129
Agropyron repens, 12: 169
Agrostis
  alba, 12: 169
  calamagrostis, 11: 29
  gigantea, 12: 169
Ahlberg, Rodger A. (see Donald W. Davidson et al.)
Allegan County, Michigan, 12: 217-234
Aleuria
  acetabulum, 11: 159
  cestrica, 12: 197
  leucomelas, 11: 158
  macropus, 11: 164
Allmendinger, Elizabeth, 11: 35
Amanita
  aestivalis, 10: 129
  brunnescens, 10: 129
  citrina, 10: 129
  cothurnata, 10: 129
  flavoconia, 10: 129
  fulva, 10: 129
  gemmata, 10: 129
  muscaria, 10: 129
  verna, 12: 197
  virosa, 10: 129
Amblystegium
  juratzkanum, 10: 16; 11: 10
  serpens, 11: 10; 12: 214

varium, 10: 10, 16; 11: 10
Ammirati, Joseph F., Jr., & Alexander H. Smith, Studies in the Genus Cortinarius, II: Section Dermocybe, New and Interesting Species from Michigan, 11: 13-25
Ammophila breviligulata, 11: 216
Amnicon Falls State Park, Douglas County, Wisconsin, The Bryophytes of, 12: 212-216
Analysis of a Terrestrial Lichen Population at Grass Lake, Missaukee County, Michigan, 11: 202-206
Andersen, Nancy M., & Raymond E. Hampton, Analysis of a Terrestrial Lichen Population at Grass Lake, Missaukee County, Michigan, 11: 202-206
Andromeda glaucophylla, 10: 83
Andropogon nutans, 11: 31
Angiosperm Orders, Mnemonics for Learning, 11: 207-211
Anomodon
attenuatus, 10: 5; 11: 10; 12: 214
minor, 10: 10
rostratus, 10: 5, 12; 11: 10; 12: 214
viticulosus, 10: 5
Aquatic Plants in Northwestern Minnesota, Observations on Some, 10: 117-124
Aquilegia canadensis, 12: 230
Arabis
lyrata, 12: 169
perstellata, 12: 89
Arctostaphylos uva-ursi, 12: 169
Armillaria mellea, 10: 64, 66, 131
Arthopyrenia
cavata, 12: 11
submuriformis, 12: 15
willeyana, 12: 16
Arundo
australis, 11: 31
calamagrostis, 11: 29
halleri, 11: 28-29
neglecta, 11: 28-29
phragmites, 11: 31
stricta, 11: 29
Asclepias
exaltata, 12: 230
syriaca, 12: 256
×Asplenosorus inexpectatus, 12: 89
Aster in Michigan, The Genus, 1. Distribution of the Species, 10: 99-106
Athyrium
angustum, 10: 196
pycnocarpon, 10: 195
thelypteroides, 10: 195
Atrichum
altecristatum, 11: 11
angustatum, 11: 11
oerstedianum, 11: 11
undulatum, 10: 17; 11: 11; 12: 214
Aulacomnium
heterostichum, 11: 9
palustre, 10: 7, 15, 84; 11: 9
Aureolaria flava, 10: 191
Authors, Information for, 12: 142
Azolla caroliniana, 11: 67

Badhamia utricularis, 12: 197
Barbilophozia barbata, 10: 5
Barbula
fallax, 11: 9
unguiculata, 11: 9; 12: 214
Bark Morphology of Yellow Birch in an Even-Aged Stand, Variability in, 10: 34-38
Barnes, Burton V., & Bruce P. Dancik, Variability in Bark Morphology of Yellow Birch in an Even-Aged Stand, 10: 34-38
Bartramia pomiformis, 11: 9; 12: 214
Batts, H. Lewis, Jr., 11: 66
Bazzania trilobata, 10: 10
Beal, W. J., 11: 5; 12: 199
Beal Botanical Garden Centennial, 12: 199
Beaver Island, Charlevoix County, Michigan, Pteridophytes of, 10: 194-196
Becker, H. R., 11: 5
Bergamot, Wild, 10: 204
Beschel, Roland E., 10: 95
Betula
alleghaniensis, 10: 34-38
papyrifera, 10: 66; 12: 169
pumila, 10: 83
Bigelow, Wilbur C. (see Jane Taylor et al.)
Billington, Cecil, 11: 63
Biosystematics and Ecology of the Genus Brachyelytrum (Gramineae) in Michigan, The, 10: 19-33
Blasia pusilla, Comparative Micromorphology of Spore and Elater Ornamentation in, 12: 129-132
Blepharistoma trichophyllum, 10: 6-7, 11; 11: 6
Blindia acuta, 10: 4
Bloodroot, 12: 144
Blum, John L., Mnemonics for Learning Angiosperm Orders, 11: 207-211
Boletus
affinis, 10: 129
castanellus, 10: 76
ornatipes, 10: 129
piperatus, 10: 129
subtomentosus, 10: 129
truncatus, 10: 129
Botrychium
lanceolatum, 10: 195
lunaria, 10: 195
matricariaefolium, 10: 195
minganense, 10: 195
multifidum, 10: 195
simplex, 10: 195
virginianum, 10: 195
Bourdo, Eric, 10: 142
Boyce, David A. (see Richard Brewer et al.)
Brachyelytrum erectum, 10: 19-33
Brachyelytrum (Gramineae) in Michigan, The Biosystematics and Ecology of, 10: 19-33

Brachythecium
acuminatum, 11: 10; 12: 214
oxycladon, 10: 6, 10-12; 11: 10; 12: 214
plumosum, 10: 6-7; 11: 10; 12: 214
rivulare, 11: 10; 12: 214
rutabulum, 10: 17; 11: 10
salebrosum, 10: 17; 12: 214
turgidum, 10: 7, 12
Braun, Annette, 12: 83, 98, 104
Braun, E. Lucy, 11: 47
Braun, E. Lucy (1889-1971), Outstanding Botanist and Conservationist: A Biographical Sketch, with Bibliography, 12: 83-106
Braun, E. Lucy, Plants Named by or for, 12: 89
Brewer, Richard, David A. Boyce, James R. Hodgson, Jerome D. Wenger, Michael H. Mills, & Murray M. Cooper, Composition of Some Oak Forests in Southwestern Michigan, 12: 217-234
Britton, D. M., & T. Reznicek, Chromosome Studies on the Spring Beauties, Claytonia, in Ontario, 10: 51-62
Bromus
canadensis, 11: 28
ciliatus, 11: 28
kalmii, 11: 28
latiglumis, 11: 28
pubescens, 11: 28
purgans, 11: 28
Brotherella
recurvans, 10: 10, 17
tenuirostris, 11: 11
Bryhnia
graminicolor, 11: 10
novae-angliae, 10: 10; 11: 10; 12: 214
Bryoerythrophyllum recurvirostrum, 10: 6, 12; 11: 9; 12: 108, 110, 113
Bryophyte Florula of an Area near Grand Ledge, Eaton County, Michigan, A, 11: 3-12
Bryophytes of Amnicon Falls State Park, Douglas County, Wisconsin, The, 12: 212-216
Bryophytes from Summer Island, Delta County, Michigan, A Collection of, 10: 3-13
Bryum
angustirete, 11: 9
argenteum, 10: 10, 15; 11: 9
caespiticium, 11: 9; 12: 214
capillare, 10: 6, 11; 11: 9
pseudotriquetrum, 10: 8, 15; 12: 214
uliginosum, 12: 214
Bulbostylis capillaris, 11: 31
Burdock, 10: 200
Bush Clover, Round-headed, 10: 204
Buxbaumia
aphylla, 11: 11, 70-73
minakatae, 11: 70
Buxbaumia aphylla in the Douglas Lake Region of Michigan, The Habitat and Orientation of Capsules of, 11: 70-73
Buzzardroost Rock, 12: 92-93
Byron Bog, Southwestern Ontario, The Distribution of Mosses in, 10: 14-18

Cain, Stanley A., & W. H. Wagner, Jr., Dale J. Hagenah (1908-1971): An Outstanding Michigan Botanist, 11: 60-66
Calamagrostis
neglecta, 11: 28-29
stricta, 11: 28-29
Callicladium haldanianum, 12: 214
Calliergon
cordifolium, 10: 16
giganteum, 10: 8
Calliergonella cuspidata, 11: 10; 12: 214
Calocerea cornea, 12: 197
Caloplaca cerina, 12: 163
Calvatia
cyathaformis, 10: 130
tatrensis, 10: 130
Calypogeia fissa, 11: 6
Calypso bulbosa, 12: 200
Campbell, Ella O., Notes on the Fungal Association of Two Monotropa Species in Michigan, 10: 63-67
Campylium
chrysophyllum, 10: 6; 11: 10
hispidulum, 10: 6; 11: 10; 12: 214
polygamum, 10: 8; 11: 10
radicale, 10: 16
stellatum, 10: 8
Candelaria fibrosa, 12: 163
Cantharellus
cibarius, 10: 75, 129
cinnabarinus, 10: 129
Carex, 11: 31-33
acuta, 11: 31
canescens, 10: 83
concinna, 11: 143
concolor, 12: 163
gracillima, 12: 169
hirta, 11: 32
interior, 10: 83
lasiocarpa, 10: 83
limosa, 10: 83
pensylvanica, 12: 230
pulicaris, 11: 32
rostrata, 10: 83
rugosperma, 12: 169
stricta, 10: 83
umbellata, 12: 169
Carpinus caroliniana, 12: 229
Carya
alba, 12: 203-205, 207
amara, 12: 203-204
cordiformis, 12: 204-205
glabra, 12: 204
laciniosa, 12: 204, 207
ovalis, 12: 204-205, 207, ?229
ovata, 12: 204-205, 207
porcina, 12: 203-204
tomentosa, 12: 203-209

Case, Fred W., Jr., 10: 142
Case, Fred W., Jr., with William Schwab, Isotria medeoloides, the Smaller Whorled Pogonia, in Michigan, 10: 39-43
Cassia hebecarpa var. longipila, 12: 89
Catoscopium nigritum, 10: 12-13; 11: 126-127
Cat-tail, Common, 10: 199-200
Ceanothus americanus, 12: 229
Cephalozia
bicuspidata, 11: 7
media, 10: 12; 11: 7
pleniceps, 11: 7
Cephaloziella
hampeana, 11: 7
rubella, 11: 7
sullivantii, 10: 12
Ceratodon purpureus, 10: 13, 15; 11: 8; 12: 168, 170, 174, 214
Chamaedaphne calyculata, 10: 83
Changing Abundance of Two Species of Linum in Eastern North America, 10: 113-116
Charlevoix County, Michigan, Pteridophytes of Beaver Island, 10: 194-196
Cheney, L. S., 10: 148
Chiloscyphus pallescens, 10: 6, 8; 11: 7; 12: 216
Chimaphila umbellata, 12: 229
Chionapsis corni, 11: 74-75, 77
Chromosome Numbers in Clintonia borealis (Liliaceae), 12: 122-128
Chromosome Studies of Some Mosses of the Douglas Lake Region. II, 11: 125-128; III, 12: 107-117
Chromosome Studies on the Spring Beauties, Claytonia, in Ontario, 10: 51-62
Chrysanthemum leucanthemum, 12: 169
Chrysophyceae, Studies on Michigan, I, 11: 51-59; II, 12: 118-122
Chrysosphaerella, 11: 55, 57
brevispina, 11: 57, 59
longispina, 11: 57, 59
multispina, 11: 57
Cincinnati Wild Flower Preservation Society, 12: 84, 91, 94-95
Circulation of The Michigan Botanist, 10: 143
Cirriphyllum
illecebrum, 11: 212
piliferum, 10: 17
Cladonia
capitata, 11: 204-206
chlorophaea, 10: 84; 11: 204-206; 12: 169
cornuta, 12: 169
cristatella, 11: 204-206; 12: 169
fimbriata, 11: 204-206; 12: 169
gracilis, 12: 169
mitis, 12: 169
pyxidata, 11: 204-206
rangiferina, 11: 204-206; 12: 169
uncialis, 12: 169
verticillata, 11: 204-206; 12: 169
Cladopodiella fluitans, 11: 7
Claudopus, 10: 131
Clauson, Andrew, & Terry R. Haas, Vertical Distribution of the Lichen Genus Physcia on Bigtooth Aspen, Northern Red Oak, and Red Maple at Douglas Lake, Michigan, 11: 39-42
Clavaria
cinerea, 10: 129
pyxidata, 10: 129
vermicularis, 12: 196
Clavariadelphus junceus in Central Michigan, 12: 235-236
Clavulina
cinerea, 12: 197
cristata, 12: 196
Claytonia
caroliniana, 10: 31, 51-62
virginica, 10: 31, 51-62
Claytonia in Ontario, Chromosome Studies on, 10: 51-62
Climacium
americanum, 11: 10
dendroides, 10: 8, 16, 84; 12: 214
Clintonia
alleghaniensis, 12: 122
andrewsiana, 12: 122
borealis, 12: 122-128
udensis, 12: 122
uniflora, 12: 122
Clintonia borealis (Liliaceae), Chromosome Numbers in, 12: 122-128
Clitocybe
adirondackensis, 10: 131
candicans, 10: 131
candida, 10: 131
clavipes, 10: 131
gibba, 10: 131
metachroa, 10: 131
squamulosa, 10: 65
subconnexa, 10: 131
umbonata, 10: 131
Cobbe, Thomas J., 12: 96
Cochrane, Theodore S. (see Lytton J. Musselman et al.)
Collection and Study of Higher Fungi, An Introduction to the, 10: 89-93
Collection of Bryophytes from Summer Island, Delta County, Michigan, A, 10: 3-13
Collybia
butyracea, 10: 131
cylindrospora, 10: 131
dryophila, 10: 131; 12: 197
radicata, 10: 131
velutipes, 12: 196
Cololejeunea biddlecomiae, 10: 6, 12
Comandra umbellata, 12: 230
Comparative Micromorphology of Spore and Elater Ornamentation in Blasia pusilla, 12: 129-132
Composition of Some Oak Forests in Southwestern Michigan, 12: 217-234

Comptonia peregrina, 10: 191; 12: 229
Conocephalum conicum, 10: 11; 11: 7; 12: 216
Cook, F. S., The Distribution of Mosses in the Byron Bog, Southwestern Ontario, 10: 14-18
Cook, F. S., & William G. Stewart, Four Interesting Moss Records from Southwestern Ontario, 11: 212-213
Cooper, Murray M. (see Richard Brewer et al.)
Coprinus
lagopus, 12: 197
micaceus, 10: 130; 12: 196
radians, 10: 130
Cornus
florida, 12: 219-228
stolonifera, 11: 74-75, 77
Cornus, A Rare Septobasidium on Scale Insects on, Found in Michigan, 11: 74-77
Corticolous Pyrenolichens of the Great Lakes Region, The, 12: 3-68
Cortinarius
chrysolitus, 11: 21
huronensis, 11: 14, 20-21, 24
var. **olivaceus**, 11: 14, 21-24
incognitus, 11: 14, 16, 18-20
obtusus, 10: 130
pellstonianus, 11: 13-14
subcroceofolius, 11: 14-16
var. **sordipes**, 11: 14, 17-18
trivialis, 10: 130
tubarius, 11: 14, 22-24
var. **luteofolius**, 11: 14, 24
uliginosus, 11: 13, 25
Cortinarius, Studies in the Genus, II: Section Dermocybe, New and Interesting Species from Michigan, 11: 13-25
Corylus americana, 12: 230
Costapedia, 11: 155
Cowlesia, 11: 155
corium, 11: 167
macropus, 11: 164
Cranbrook Institute of Science, 11: 61-62
Crandall, Albert Rogers, 10: 148
Cratoneuron filicinum, 10: 8, 16; 11; 10; 12: 214
Crego, Alanzo, 11: 141-142
Crepidotus mollis, 10: 130
Crum, Howard, Leucobryum albidum New to Michigan, 12: 117; Mosses New to the State of Michigan, 11: 123-124
Curtis, J. T., 10: 148
Cyathipodia, 11: 155
corium, 11: 167
macropus, 11: 164
villosa, 11: 172
Cypridepium acaule, 12: 230
Cyrus H. McCormick Experimental Forest, 10: 94-96, 142
Cystoderma amianthinum, 10: 131
Cystopteris
bulbifera, 10: 196
dickieana, 11: 64
fragilis, 10: 195; 11: 64
protrusa, 11: 64

Daedalea
confragosa, 10: 130
quercina, 12: 197
Daldinia concentrica, 10: 129
Dale J. Hagenah (1908-1971): An Outstanding Michigan Botanist, 11: 60-66
Dalve, Elizabeth, 12: 96, 98
Dancik, Bruce P., & Burton V. Barnes, Variability in Bark Morphology of Yellow Birch in an Even-Aged Stand, 10: 34-38
Danthonia spicata, 12: 169
Darlington, H. T., 11: 5
Davidson, Donald W., Rodger A. Ahlberg, Rudy G. Koch, & Duane J. Lahti, A Westward Extension of Hemlock in Wisconsin, 12: 209-211
Davis, J. J., 10: 148
Delicatula integrella, 12: 197
Delta County, Michigan, A Collection of Bryophytes from Summer Island, 10: 3-13
Desmatodon obtusifolius, 11: 9
Desmodium
nudiflorum, 12: 230
paniculatum, 12: 230
rotundifolia, 12: 230
Dicranella
heteromalla, 10: 11, 15; 11: 8; 12: 107-109, 112
schreberiana, 12: 213-214
varia, 12: 214
Dicranum
bonjeanii, 10: 15
flagellare, 10: 6; 11: 8; 12: 214
fulvum, 11: 8
montanum, 10: 12, 15; 11: 8; 12: 214
polysetum, 10: 8, 11, 15; 11: 8, 126-127; 12: 214
rugosum, 11: 126
scoparium, 10: 6, 11, 13, 15; 11: 8; 12: 214
undulatum, 10: 15
viride, 12: 214
Didymodon
rigidulus, 10: 6, 13
tophaceus, 11: 9
Diplophyllum apiculatum, 11: 7
Diphysium foliosum, 11: 11
Discina, 12: 154-155, 160
caroliniana, 12: 150, 160
leucoxantha, 12: 149
Duncan, Thomas, Forty Years of Succession on an Abandoned Building Site at the University of Michigan Biological Station, 12: 167-177
Distichium
capillaceum, 10: 6, 13; 12: 214
inclinatum, 12: 214

Distribution of Mosses in the Byron Bog, Southwestern Ontario, The, 10: 14-18
Distribution maps:
Arthopyrenia biformis, 12: 62
Arthopyrenia finkii, 12: 62
Arthopyrenia willeyana, 12: 63
Aster ×amethystinus, 10: 103
Aster azureus, 10: 103
Aster brachyactis, 10: 103
Aster ciliolatus, 10: 103
Aster cordifolius, 10: 103
Aster dumosus, 10: 103
Aster ericoides, 10: 103
Aster junciformis, 10: 104
Aster laevis, 10: 104
Aster lateriflorus, 10: 104
Aster lowrieanus, 10: 104
Aster macrophyllus, 10: 104
Aster modestus, 10: 104
Aster nemoralis, 10: 104
Aster novae-angliae, 10: 104
Aster patens, 10: 105
Aster pilosus, 10: 105
Aster praealtus, 10: 105
Aster ptarmicoides, 10: 105
Aster puniceus, 10: 105
Aster sagittifolius, 10: 105
Aster schreberi, 10: 105
Aster sericeus, 10: 106
Aster shortii, 10: 106
Aster simplex, 10: 106
Aster subulatus, 10: 106
Aster tardiflorus, 10: 106
Aster tradescanti, 10: 106
Aster umbellatus, 10: 106
Aster vimineus, 10: 106
Brachyelytrum erectum, 10: 30
Carya tomentosa, 12: 206
Claytonia caroliniana, 10: 56
Claytonia virginica, 10: 57
Clintonia borealis, 12: 124
Clintonia umbellulata, 12: 124
Eopyrenula leucoplaca, 12: 63
Gyromitra brunnea, 12: 159
Gyromitra caroliniana, 12: 159
Leptorhaphis epidermidis, 12: 64
Mycoporum pycnocarpum, 12: 64
Ophioglossum vulgatum, 10: 72
Plagiocarpa hyalospora, 12: 65
Polyblastiopsis fallaciosa, 12: 65
Pyrenula imperfecta, 12: 67
Pyrenula neglecta, 12: 66
Trypethelium virens, 12: 67
Tsuga canadensis, 12: 210
Ditrichum
flexicaule, 10: 8, 13
pallidum, 10: 15; 11: 8
Douglas Lake, Michigan, The Importance of Turions in the Propagation of Myriophyllum exalbescens (Haloragidaceae) in, 11: 115-121
Douglas Lake, Michigan, Vertical Distribution of the Lichen Genus Physcia on Bigtooth Aspen, Northern Red Oak, and Red Maple at, 11: 39-42
Douglas Lake Region, Chromosome Studies of Some Mosses of, II, 11: 125-128; III, 12: 107-117
Douglas Lake Region of Michigan, The Habitat and Orientation of Capsules of Buxbaumia aphylla in the, 11: 70-73
Douglass, David Bates, 11: 121-122
Draba ramosissima var. glabrifolia, 12: 89
Drepanocladus
aduncus, 10: 8; 11: 10; 12: 214
fluitans, 10: 16
revolvens, 10: 8, 13
sendtneri, 10: 8
uncinatus, 10: 16; 12: 108, 111, 214
vernicosus, 10: 8
Dryodon, 12: 178
caput-ursi, 12: 182
coralloides, 12: 179
erinaceus, 12: 188
Drosera rotundifolia, 10: 83
Dryopteris
assimilis, 11: 64
cristata, 10: 196
intermedia, 10: 196
marginalis, 10: 196
spinulosa, 10: 196
Dulichium arundinaceum, 10: 83

E. Lucy Braun (1889-1971), Outstanding Botanist and Conservationist: A Biographical Sketch, with Bibliography, 12: 83-106
Eaton County, Michigan, A Bryophyte Florula of an Area near Grand Ledge, 11: 3-12
Elater Ornamentation in Blasia pusilla, Comparative Micromorphology of Spore and, 12: 129-132
Eleocharis calva, 10: 83
Elvella underwoodii, 12: 147
Encalypta
ciliata, 11: 9; 12: 214
procera, 10: 6
Entodon seductrix, 11: 10
Entoloma subserrulatum, 10: 131
Eopyrenula, 12: 19, 21
leucoplaca, 12: 19, 80
Epilobium
angustifolium, 12: 175
palustre, 10: 83
Epipactis helleborine, 11: 36
Equisetum
arvense, 10: 195
×ferrissii, 10: 195
fluviatile, 10: 83, 195
hyemale, 10: 195
palustre, 10: 195
scirpoides, 10: 195
sylvaticum, 10: 195
variegatum, 10: 195
Erigeron pulchellus var. brauniae, 12: 89

Eriophorum
gracile, 10: 83
spissum, 10: 83
Eucladium verticillatum, 10: 5, 6
Eupatorium
deltoides, 12: 89
luciae-brauniae, 12: 89
Eurhynchium
hians, 10: 17; 11: 10
pulchellum, 10: 11; 11: 10; 12: 215

Fagus grandifolia, 12: 229
Fairy-slipper Orchid, 12: 200
Farwell, Olive, 12: 69-72
Farwell, Oliver A., 11: 64; 12: 207
Farwell, Oliver Atkins—A Reflection, 12: 69-73
Fassett, Norman C., 10: 148
Fastigiella caroliniana, 12: 150
Favolus alveolaris, 10: 130; 12: 196-197
Federation of Ontario Naturalists, 10: 47
Fell, Egbert W., 10: 148
Festuca
amethystina, 11: 29
capillata, 11: 29
ovina, 11: 29; 12: 169
tenuifolia, 11: 29
Festucoideae: Festuceae, 11: 27
Field Key to Some Common Shrubs and Vines of Michigan, 11: 129-139
Fimbristylis
autumnalis, 11: 31
caroliniana, 11: 33
drummondii, 11: 33
puberula, 11: 33
spadicea, 11: 33
Fissidens
adiantoides, 10: 13
bushii, 11: 11
cristatus, 10: 11, 13; 12: 215
exilis, 11: 8
minutulus, 11: 8
obtusifolius, 11: 11
osmundoides, 10: 8, 10, 12; 12: 107-108, 215
taxifolius, 11: 8, 11; 12: 215
viridulus, 11: 8; 12: 215
Flora of Rock County, Wisconsin, The, 10: 147-193
Floral Phenology at the Matthaei Botanical Gardens: 1969-1971, 11: 83-114
Fomes
applanatus, 12: 197
fomentarius, 10: 130
ignarius, 12: 197
Fontinalis
antipyretica, 10: 4
dalecarlica, 11: 123
hypnoides, 12: 215
sphagnifolia, 11: 123
Forty Years of Succession on an Abandoned Building Site at the University of Michigan Biological Station, 12: 167-177
Four Interesting Moss Records from Southwestern Ontario, 11: 212-213
Friesites, 12: 178
caput-ursi, 12: 182
Frostic, Gwen, 11: 66
Frullania
bolanderi, 10: 11
brittoniae, 10: 11
eboracensis, 11: 7
Fuckelina, 11: 155
corium, 11: 167
villosa, 11: 172
Fuller, Albert M., 10: 148
Fulton, Doug, 11: 66
Funaria hygrometrica, 10: 12, 15; 11: 9; 12: 215
Fungal Association of Two Monotropa Species in Michigan, Notes on the, 10: 63-67
Fungi, An Introduction to the Collection and Study of the Higher, 10: 89-93
Fungi of Lower Huron Metropolitan Park in Wayne County, Michigan, 12: 195-198
Fungi of 1970, Some Rare or Unusual Michigan, 10: 75-77

Ganoderma applanatum, 10: 130
Gates, David M., 10: 95
Gaultheria procumbens, 12: 229
Gaylussacia baccata, 12: 169, 230
Geisler, Sylvia, 12: 96
Genus Aster in Michigan, The, 1. Distribution of the Species, 10: 99-106
Genus Helvella in Michigan, The, 11: 147-201
Genus Hericium in North America, The, 12: 177-194
Geocalyx graveolens, 10: 8, 10; 11: 7
Geoglossum difforme, 10: 129
Gerardia flava, 10: 191
Globopilea, 11: 155
phlebophora, 11: 182
Glyceria borealis, 10: 83
Goodyera
pubescens, 11: 36
tesselata, 11: 36
Grand Ledge, Eaton County, Michigan, A Bryophyte Florula of an Area near, 11: 3-12
Grass Lake, Missaukee County, Michigan, Analysis of a Terrestrial Lichen Population at, 11: 202-206
Greene, Henry C., 10: 148
Grimmia
alpicola, 11: 9
apocarpa, 12: 215
plagiopodia, 11: 212
pulvinata, 11: 212
Gymnocarpium dryopteris, 10: 196
Gymnoconia peckiana, 12: 197
Gymnopilus penetrans, 10: 130
Gymnosporangium globosum, 12: 196
Gymnostomum
aeruginosum, 10: 6; 11: 9, 11

recurvirostrum, 10: 13; 11: 9; 12: 108-110, 215
rupestre, 11: 9
Gyromitra
ambigua, 12: 155
antarctica, 12: 155
brunnea, 12: 147-162
caroliniana, 12: 147-162
costata, 12: 156-157
curtipes, 12: 158
esculenta, 12: 154
fastigiata, 12: 153-155, 158-160
gigas, 12: 153-155, 157-160
infula, 12: 155
labyrinthica, 12: 157
sphaerospora, 12: 157
tasmanica, 12: 155
Gyromitra (False Morel) in North America, Two Misunderstood Species of, 12: 147-162
Gyroporus castaneus, 10: 75

Haas, Terry R., & Andrew Clauson, Vertical Distribution of the Lichen Genus Physcia on Bigtooth Aspen, Northern Red Oak, and Red Maple at Douglas Lake, Michigan, 11: 39-42
Habenaria
×bicolor, 11: 35
blephariglottis × ciliaris, 11: 35
lacera, 11: 36
leucophaea, 10: 208; 11: 36, 208
psycodes, 11: 36
×schweinfurthii, 11: 35
Habitat and Orientation of Capsules of Buxbaumia aphylla in the Douglas Lake Region of Michigan, The, 11: 70-73
Halbert, Richard L., & Norton G. Miller, A Collection of Bryophytes from Summer Island, Delta County, Michigan, 10: 3-13
Hagenah, Dale J., 11: 47
Hagenah, Dale J. (1908-1971): An Outstanding Michigan Botanist, 11: 60-66
Hale, Thomas J., 10: 148
Hamamelis virginiana, 12: 229
Hamilton, Ralph, & Daniel E. Wujek, Studies on Michigan Chrysophyceae. I, 11: 51-59; II, 12: 118-122
Hampton, Raymond E., & Nancy M. Andersen, Analysis of a Terrestrial Lichen Population at Grass Lake, Missaukee County, Michigan, 11: 202-206
Hanes, Mr. & Mrs. Clarence R., 11: 64
Haplocladium microphyllum, 12: 215
Harris, Richard C., The Corticolous Pyrenolichens of the Great Lakes Region, 12: 3-68
Harrison, K. A., The Genus Hericium in North America, 12: 177-194; A Rare Septobasidium on Scale Insects on Cornus Found in Michigan, 11: 74-77
Hedwigia ciliata, 11: 10; 12: 215
Helianthus divaricatus, 12: 230
Helodium blandowii, 10: 8, 84; 12: 215
Helvella, 11: 147-156
acetabulum, 11: 159-162
albella, 11: 195-198
atra, 11: 178-179; 12: 156
caroliniana, 12: 150, 158
connivens, 11: 193, 195
corium, 11: 167-169
costata, 12: 150, 156, 158
crispa, 11: 198-200; 12: 197
cupuliformis, 11: 174-175
elastica, 11: 191-193; 12: 156
ephippium, 11: 176
esculenta, 10: 129
fastigiata, 12: 157, 159-160
gigas, 12: 157-160
griseoalba, 11: 162-163
inflata, 12: 157
lacunosa, 11: 186-189
leucomelaena, 11: 158-159
macropus, 11: 164-167
nigra, 11: 167
pallidula, 11: 171
palustris, 11: 189-191
pezizoides, 11: 176-178; 12: 156
phlebophora, 11: 182-183
queletii, 11: 169-171
stevensii, 11: 193-195
subglabra, 11: 179
sulcata, 11: 183-186
underwoodii, 12: 157
villosa, 11: 172-174
Helvella in Michigan, The Genus, 11: 147-201
Hemitrichia clavata, 12: 197
Hemlock in Wisconsin, A Westward Extension of, 12: 209-211
Hepatica americana, 12: 230
Hericium, 12: 178-179
abietis, 12: 186, 190-193
caput-ursi, 12: 181-182
clathroides, 12: 183
coralloides, 12: 178-183, 186, 188, 192-193
erinaceus, 12: 188-190
laciniatum, 12: 182-183
ramosum, 12: 182-188
weirii, 12: 190
Hericium in North America, The Genus, 12: 177-194
Herzogiella turfacea, 12: 109, 114-115
Heteranthera dubia, 10: 117-118
Heterophyllium haldanianum, 10: 11, 17; 11: 11
Hicoria alba, 12: 203, 205
Hieracium aurantiacum, 12: 169
Hodgson, James R. (see Richard Brewer et al.)
Hollingsworth, Peggie J. (see Jane Taylor et al.)
Homomallium adnatum, 10: 6, 12; 11: 11
Hosency, Florence V., Some Rare or Unusual Michigan Fungi of 1970, 10: 75-77

Hosie, R. C., 12: 205
Humarina
rubens, 12: 197
testacea, 12: 197
Hydnum, 12: 178
abietinum, 12: 178
abietis, 12: 190, 192
alpestre, 12: 179, 181
caput-medusae, 12: 188-189
caput-ursi, 12: 181-182
clathroides, 12: 178
coralloides, 12: 178-179, 182
crispum, 12: 178
erinaceus, 12: 188
laciniatum, 12: 178
muscoides, 12: 178
ramosum, 12: 178, 182
Hygroamblystegium
fluviatile, 11: 10
tenax, 10: 8; 12: 215
Hygrohypnum luridum, 10: 12, 16
Hygrophorus
acutoconicus, 10: 130
borealis, 10: 130
cantharellus, 10: 130; 12: 197
conicus, 10: 130; 12: 197
flavescens, 10: 130; 12: 197
laetus, 10: 130; 12: 197
marginatus, 10: 130
nitidus, 10: 130
parvulus, 12: 197
pratensis, 10: 130
psittacinus, 10: 130; 12: 196
subviolaceus, 10: 130
Hylocomium splendens, 10: 8; 12: 215
Hypericum virginicum, 10: 83
Hypnum
cupressiforme, 10: 6, 12
curvifolium, 11: 11
fertile, 12: 215
imponens, 10: 17; 12: 215
lindbergii, 10: 8, 10, 84; 11: 11; 12: 215
pallescens, 10: 10, 17; 12: 109, 114-115, 215
pratense, 10: 12
Hypomyces
cervinigenus, 10: 109
chrysospermus, 10: 112
chrysostomus, 10: 109
luteovirens, 10: 112
melanocarpus, 10: 108-110
porphyreus, 10: 107-108, 110
tulasneanus, 10: 112
Hypomyces from Michigan, Two New Species of, 10: 107-113

Iltis, Hugh H., 10: 148
Importance of Turions in the Propagation of Myriophyllum exalbescens (Haloragidaceae) in Douglas Lake, Michigan, The, 11: 115-121
Information for Authors, 12: 142
Inocybe lacera, 10: 130
International Botanical Congress, XII, 12: 141
Introduction to the Collection and Study of Higher Fungi, An, 10: 89-93
Irwin, N. Mildred, 12: 96
Isle Royale, Orchids of, 11: 36
Isoetes muricata, 10: 195
Isopaches hellerianus, 10: 8, 12
Isopterygiopsis muelleriana, 11: 123-124
Isopterygium
distichaceum, 11: 11
subfalcatum, 11: 11
turfaceum, 10: 12, 17; 12: 115
Isotria
medeoloides, 10: 39-43
verticillata, 10: 39-41
Isotria medeoloides, the Smaller Whorled Pogonia, in Michigan, 10: 39-43
Itasca Park, Minnesota, The Marshall Bog near, 10: 78-88

Jamesoniella autumnalis, 10: 8, 11; 11: 7
Jimsonweed, 10: 203
Joyal, Robert, The Marshall Bog near Itasca Park, Minnesota, 10: 78-88
Juncus
dudleyi, 11: 34
interior, 11: 34
var. uniflorus, 11: 34
tenuis, 11: 34
var. billingtonii, 11: 34
var. uniflorus, 11: 34
Jungermannia
amakawana, 10: 9
lanceolata, 10: 8
leiantha, 10: 8, 10; 11: 7
subulata, 10: 9

Kalkaska County, Michigan, A Sample of the Seasonal Occurrence of Higher Fungi in, 10: 125-136
Kalm, [Pehr], 11: 30
Key, Field, to Some Common Shrubs and Vines of Michigan, 11: 129-139
Key, Summer Field, to Some Common Michigan Trees, 10: 137-141
King, Elizabeth, 12: 98
Koch, Rudy G. (see Donald W. Davidson et al.)
Koch, Rudy G., & Gary J. Schroeder, The Bryophytes of Amnicon Falls State Park, Douglas County, Wisconsin, 12: 212-216
Koeleria
cristata, 11: 29
macrantha, 11: 29
Kruschke, Emil P., 10: 148

Laccaria
amethystina, 10: 131; 12: 197
laccata, 10: 131; 12: 197
Lachnea
corium, 11: 167
macropus, 11: 164

Lactarius
camphoratus, 10: 131
deceptivus, 10: 131
mutabilis, 10: 131
subdulcis, 12: 197
trivialis, 10: 131
vellerius, 10: 131; 12: 197
Lahti, Duane J. (see Donald W. Davidson et al.)
Lampky, James, Clavariadelphus junceus in Central Michigan, 12: 235-236
Lapham, Increase A., 10: 147-148
Larix laricina, 10: 83
LaRue, Jane I., An Introduction to the Collection and Study of Higher Fungi, 10: 89-93; A Sample of the Seasonal Occurrence of Higher Fungi in Kalkaska County, Michigan, 10: 125-136
Lathrop, Stephen Pearl, 10: 148
Lea, Thomas G., 12: 88
Lecanora
glabrata, 12: 163
varia, 12: 163
Leccinum
insigne, 10: 129
pseudoinsigne, 10: 129
scabrum, 10: 129
snellii, 10: 129
Ledum groenlandicum, 10: 83
Leiocolea muelleri, 10: 5
Lejeunea cavifolia, 10: 12; 11: 7
Lemna minor, 11: 67, 69
Lentinellus bisus, 10: 131
Lenzites betulina, 12: 196
Leotia lubrica, 10: 77, 129
Lepidium
densiflorum, 12: 169
virginicum, 12: 169
Lepidozia reptans, 10: 9-10
Lepiota
cristata, 12: 197
rhacodes, 12: 196
Leptobryum pyriforme, 11: 9
Leptodictyum
riparium, 10: 16
trichopodium, 11: 10, 16; 12: 215
Leptonia, 10: 131
strigosissima, 10: 109
Leptopodia, 11: 155
albella, 11: 195
atra, 11: 178
elastica, 11: 191
ephippium, 11: 176
pezizoides, 11: 176
stevensii, 11: 193
Leptospermum scoparium, 10: 66
Leskea
gracilescens, 10: 16; 11: 10
polycarpa, 10: 16
Leskeella nervosa 10: 6, 12; 11: 10
Leucobryum
albidum, 12: 117
glaucum, 10: 10; 11: 8; 12: 117
Leucobryum albidum New to Michigan, 12: 117
Leucodon sciuroides, 10: 11, 12
LeVee, Gordon J. (see Jane Taylor et al.)
Lichen Flora on Ulmus americana in Northern Michigan, The, 12: 163-166
Lichen Genus Physcia on Bigtooth Aspen, Northern Red Oak, and Red Maple at Douglas Lake, Michigan, Vertical Distribution of the, 11: 39-42
Lichen Population, Analysis of a Terrestrial, at Grass Lake, Missaukee County, Michigan, 11: 202-206
Lilium
lancifolium, 11: 34
tigrinum, 11: 34
Limacella illinita, 10: 129
Linn, Robert M., 11: 66
Linum
medium, 10: 113-116
virginianum, 10: 113-116
Linum in Eastern North America, Changing Abundance of Two Species of, 10: 113-116
Liparis liliifolia, 11: 36
Listera
convallarioides, 11: 35
smallii, 11: 35-36
Lobaria pulmonaria, 10: 144
Lolium
perenne, 11: 29-30
var. aristatum, 11: 29-30
var. italicum, 11: 30
var. multiflorum, 11: 30
multiflorum, 11: 30
Lophocolea
heterophylla, 11: 7
minor, 10: 6, 9, 13; 11: 7
Lophozia
badensis, 10: 5
barbata, 12: 216
bicrenata, 11: 7
capitata, 11: 7
collaris, 10: 5, 10
excisa, 11: 7
heterocolpos, 10: 6, 9
incisa, 10: 9, 10; 11: 7
porphyroleuca, 10: 9, 12
Lower Huron Metropolitan Park in Wayne County, Michigan, Fungi of, 12: 195-198
Ludwig, Louis K., & Edward L. McWilliams, Floral Phenology at the Matthaei Botanical Gardens: 1969-1971, 11: 83-114
Lupinus perennis, 12: 230
Lycogala
epidendrum, 12: 197
flavofuscum, 12: 197
Lycoperdon
marginatum, 10: 130
perlatum, 10: 130; 12: 197
Lycopodium, 11: 64-65
annotinum, 10: 195
appressum, 11: 65

clavatum, 10: 195
complanatum, 10: 195
flabelliforme, 10: 195
inundatum, 11: 65
lucidulum, 10: 195
obscurum, 10: 195
selago, 11: 65
tristachyum, 10: 195
Lynx Prairie, 12: 92-93
Lyophyllum loricatum, 10: 131
Lysimachia thyrsiflora, 10: 83

Macropodia, 11: 155
corium, 11: 167
macropus, 11: 164
Macroscyphus macropus, 11: 164
Mahoney, Russell, The Lichen Flora on Ulmus americana in Northern Michigan, 12: 163-166
Maianthemum canadense, 12: 230
Malaxis paludosa, 11: 36
Mallomonas, 11: 52-53
acaroides, 12: 118-119
akrokomos, 11: 52, 55
caudata, 11: 55
flora, 11: 55
monograptus, 11: 52-53
oviformis, 12: 118-119
papillosa, 11: 52-53
pseudocoronata, 11: 52
pumilo, 11: 52, 55
striata, 12: 118-119
tonsurata, 12: 120
Mallow, Indian, 10: 200
Manina, 12: 178
caput-ursi, 12: 182
coralloides, 12: 179
cordiformis, 12: 188
flagellum, 12: 182-183
Manning, Wayne E., The Northern Limit of the Distribution of the Mockernut Hickory, 12: 203-209
Marasmius
elongatipes, 12: 196
glabellus, 10: 131
oreades, 12: 197
polyphyllus, 10: 131
resinosus, 12: 197
rotula, 10: 131; 12: 196
semihirtipes, 12: 197
Marchantia polymorpha, 10: 9; 11: 7; 12: 216
Marshall Bog near Itasca Park, Minnesota, The, 10: 78-88
Matteucia pensylvanica, 10: 196
Matthaei Botanical Gardens, Floral Phenology at the: 1969-1971, 11: 83-114
Maublancomyces, 12: 160
Mazzer, Samuel J., & Clark T. Rogerson, Two New Species of Hypomyces from Michigan, 10: 107-113
McCormick, Cyrus H., Experimental Forest, 10: 94-96, 142
McElHenry, Thomas, 10: 147
McKnight, Kent H., Two Misunderstood Species of Gyromitra (False Morel) in North America, 12: 147-162
McWilliams, Edward L., & Louis K. Ludwig, Floral Phenology at the Matthaei Botanical Gardens: 1969-1971, 11: 83-114
Medusina, 12: 178
Meesia uliginosa, 10: 12; 12: 108, 110-111, 113
Melampyrum lineare, 12: 169, 230
Melanoleuca, 10: 131
alboflavida, 10: 131
Menyanthes trifoliata, 10: 83
Messner, Clarence, 11: 66
Metatrichia verparium, 12: 197
Michigan Botanical Club
Red Cedar Chapter, 10: 95, 142
Wildflowers in Winter Project, 10: 197-205; 12: 254
Michigan Botanist, The
Distribution, 10: 143
Information for Authors, 12: 142
Note on Addresses, 12: 143
Michigan Natural Areas Council, 11: 62-63
Michigan Plants in Print (see New Literature Relating to Michigan Botany)
Michigan State University, Beal Botanical Garden, 12: 199
Micromorphology, Comparative, of Spore and Elater Ornamentation in Blasia pusilla, 12: 129-132
Milkweed, Common, 10: 202; 12: 256
Miller, Norton G., A Bryophyte Florula of an Area near Grand Ledge, Eaton County, Michigan, 11: 3-12
Miller, Norton G., & Richard L. Halbert, A Collection of Bryophytes from Summer Island, Delta County, Michigan, 10: 3-13
Mills, Michael H. (see Richard Brewer et al.)
Missaukee County, Michigan, Analysis of a Terrestrial Lichen Population at Grass Lake, 11: 202-206
Mitchella repens, 12: 230
Mitrophora caroliniana, 12: 150
Mnemonics for Learning Angiosperm Orders, 11: 207-211
Mnium
affine, 10: 9, 11, 15; 11: 9
cuspidatum, 10: 15; 11: 9; 12: 215
marginatum, 10: 10; 11: 9
medium, 12: 215
orthorrhynchum, 10: 6, 9, 11; 11: 9; 12: 215
punctatum, 10: 15; 11: 9; 12: 215
spinulosum, 10: 12; 12: 215
Mockernut Hickory, The Northern Limit of the Distribution of, 12: 203-209
Monocots and Gymnosperms, Additional Nomenclatural and Other Notes on Michigan, 11: 26-36
Monotropa
hypopithys, 10: 63-67

uniflora, 10: 63-67; 12: 230
Monotropa Species in Michigan, Notes on the Fungal Association of Two, 10: 63-67
Morchella
angusticeps, 10: 129
caroliniana, 12: 150, 154, 156-157, 159-160
?deliciosa, 10: 129
esculenta, 10: 129
Morel, 10: 75
False, 12: 147-162
Moss Records from Southwestern Ontario, Four Interesting, 11: 212-213
Mosses in the Byron Bog, Southwestern Ontario, The Distribution of, 10: 14-18
Mosses of the Douglas Lake Region, Chromosome Studies of Some, II, 11: 125-128; III, 12: 107-117
Mosses New to the State of Michigan, 11: 123-124
Musselman, Lytton J., Theodore S. Cochrane, William E. Rice, & Marion M. Rice, The Flora of Rock County, Wisconsin, 10: 147-193
Mycena
alcalina, 10: 131
epipterygioides, 10: 132
gracilis, 10: 132
griseoviridis, 10: 132
latifolia, 10: 132
leaiana, 12: 197
longipes, 10: 132
pura, 10: 132
Mycoglaena myricae, 12: 29
Myriophyllum
exalbescens, 11: 115-121
verticillatum, 11: 118
Myriophyllum exalbescens (Haloragidaceae) in Douglas Lake, Michigan, The Importance of Turions in the Propagation of, 11: 115-121
Myurella
julacea, 10: 6
sibirica, 10: 6; 11: 10

Naematoloma sublateritium, 10: 131
Nature Education Feature, 10: 89-93, 137-141; 11: 129-139, 207-211; 12: 195-198
Naucoria serrulata, 10: 130
Neckera pennata, 10: 7
Neogyromitra caroliniana, 12: 150, 159-160
New Literature Relating to Michigan Botany, 10: 44-46; 11: 42-46, 78; 12: 73-78, 139-141, 254
News of Botanists, 10: 46, 95, 142; 11: 66
Nickell, Walter P., 12: 199
Nolanea, 10: 131
strictia, 10: 131
Nomenclatural and Other Notes on Michigan Monocots and Gymnosperms, Additional, 11: 26-36
Northern Limit of the Distribution of the Mockernut Hickory, The, 12: 203-209
Notes on the Fungal Association of Two Monotropa Species in Michigan, 10: 63-67
Nowellia curvifolia, 10: 12; 11: 7
Nuphar variegatum, 10: 83
Nyssa sylvatica, 12: 220-228

Oak Forests in Southwestern Michigan, Composition of Some, 12: 217-234
Observations on Some Aquatic Plants in Northwestern Minnesota, 10: 117-124
Oenothera
muricata, 12: 169
parviflora, 12: 169
Ohio Academy of Science, 12: 88, 94, 96
Ohio Flora Committee (Project), 12: 88, 94, 96
Olds, G. B., 10: 148
Oliver Atkins Farwell—A Reflection, 12: 69-73
Omphalia pyxidata, 10: 132
Oncophorus wahlenbergii, 10: 7; 11: 8; 12: 215
Onoclea sensibilis, 10: 196
Ontario Naturalists, Federation of, 10: 47
Ontario, Southwestern, Four Interesting Moss Records from, 11: 212-213
Ophioglossum vulgatum, 10: 67-74
Ophioglossum vulgatum var. pycnostichum, the Southeastern Adder's-Tongue, Found for the First Time in Michigan, 10: 67-74
Orchids of Isle Royale, 11: 36
Orthotrichum
anomalum, 10: 7, 13
obtusifolium, 10: 11; 11: 9; 12: 215
pumilum, 11: 9
sordidum, 10: 11; 12: 215
speciosum, 12: 215
stellatum, 12: 215
Osmunda
cinnamomea, 10: 196
claytoniana, 10: 196
regalis, 10: 196
Oudemansiella radicata, 12: 197

Panellus atrocoeruleus, 12: 197
Panicum
boscii, 11: 31
latifolium, 11: 30-31
macrocarpon, 11: 31
meridionale, 12: 169
Panus rudus, 12: 197
Paraphysomonas vestita, 12: 120-121
Parmelia
caperata, 12: 163
rudecta, 12: 163
sulcata, 12: 163
Parke, Davis Co., 12: 70, 73
Parker, Dorothy, 12: 96-97
Paxillus atrotomentosus, 10: 130
Paxina, 11: 155
acetabulum, 11: 159

leucomelas, 11: 158
Pedicularis canadensis, 12: 230
Peet, Robert K., The Presettlement Vegetation of Rock County, Wisconsin, 10: 150-154
Pellia
epiphylla, 11: 7
neesiana, 11: 7
Peltigera polydactyla, 10: 84; 11: 204-205
Pertusaria
amara, 12: 163
velata, 12: 163
Peziza
acetabulum, 11: 159
badia, 10: 129
corium, 11: 167
leucomelas, 11: 158
macropus, 11: 164
Phaeoceros laevis, 11: 8
Phascum cuspidatum, 11: 9
Phegopteris connectilis, 10: 196
Phenology, Floral, at the Matthaei Botanical Gardens: 1969-1971, 11: 83-114
Philonotis fontana, 10: 9; 11: 9; 12: 215
Phleboscyphus, 11: 155
acetabulum, 11: 159
Pholiota spumosa, 10: 130
Phragmites
australis, 11: 31
communis, 11: 31
Phyllitis scolopendrium, 11: 64
Phyllotopsis nidulans, 12: 197
Physcia
adscendens, 11: 39-41; 12: 163
aipolia, 11: 39-42; 12: 163
ciliata, 11: 39, 41
millegrana, 11: 39, 41
orbicularis, 11: 39, 41
pulverulenta, 11: 39, 41
setosa, 12: 163
stellaris, 11: 39-41; 12: 163
Physcia, Vertical Distribution of the Lichen Genus, on Bigtooth Aspen, Northern Red Oak, and Red Maple at Douglas Lake, Michigan, 11: 39-42
Physcomitrella patens, 11: 124
Physcomitrium pyriforme, 11: 9
Physconia grisea, 12: 163
Picea, 10: 65-66
mariana, 10: 83
Pinguicula vulgaris, 11: 143-144
Pinus
banksiana, 10: 83; 11: 26-27
divaricata, 11: 26-27
resinosa, 10: 83
strobus, 10: 83; 12: 169, 220-226
Pitcher Plant, 10: 200
Plagiocarpa, 12: 34
hyalospora, 12: 34-36
macrospora, 12: 36
phaeospora, 12: 36-37
septemseptata, 12: 37-38
Plagiochila asplenioides, 10: 7, 9, 13; 11: 7; 12: 216
Plagiopus oederiana, 10: 11
Plagiothecium
denticulatum, 10: 17; 11: 11; 12: 109, 111, 113, 115
laetum, 10: 10, 17; 12: 114-115
roeseanum, 11: 11
turfaceum, 12: 115
Platydictya
confervoides, 10: 11
jungermannioides, 10: 7
subtile, 10: 11
Platygyrium repens, 10: 11, 17; 11: 11; 12: 215
Plectocolea
crenulata, 11: 7; 12: 216
hyalina, 11: 11
Pleuridium subulatum, 11: 8
Pleurotus ostreatus, 10: 132; 12: 197
Pleurozium schreberi, 10: 7, 17; 11: 10; 12: 215
Pluteus
aurantiorugosus, 10: 76
cervinus, 10: 132; 12: 197
longistriatus, 10: 132
Poa
compressa, 12: 169
pratensis, 12: 169
Podophyllum peltatum, 12: 230
Pogonia, the Smaller Whorled, in Michigan, 10: 39-43
Pogonatum alpinum, 12: 215
Pohlia
annotina, 11: 9
cruda, 12: 215
nutans, 10: 7, 15; 11: 9; 12: 215
wahlenbergii, 11: 9; 12: 215
Polemonium reptans var. villosum, 12: 89
Pooideae: Poeae, 11: 27, 143
Polygonum erectum, 10: 191
Polypodium virginianum, 10: 196
Polyporus
adustus, 10: 130; 12: 196
albellus, 10: 130
arcularius, 12: 197
betulinus, 10: 130
cinnabarinus, 10: 130
dichrous, 10: 130: 12: 196-197
elegans, 10: 130
fagicola, 10: 130
hirsutus, 10: 130
pargamenus, 10: 130; 12: 197
perennis, 10: 131
picipes, 12: 197
planellus, 12: 197
pubescens, 12: 197
resinosus, 10: 131
squamosus, 10: 131
versicolor, 10: 131; 12: 196-197
Polystichum ×hagenahii, 11: 65
Polytrichum
commune, 10: 17, 84; 11: 11; 12: 216
formosum, 10: 17

juniperinum, 10: 18; 11: 11; 12: 169, 216
var. gracilius, 10: 4
ohioense, 10: 11; 11: 11
piliferum, 11: 11; 12: 169, 216
strictum, 10: 84
Populus
balsamifera, 10: 83
grandidentata, 10: 66; 11: 39-41; 12: 169, 220-228
tremuloides, 10: 65
Porcupine Mountains, 11: 80
Porella
platyphylla, 10: 7, 11; 11: 7
platyphylloidea, 12: 216
Potamogeton
capillaceus, 11: 27
diversifolius, 11: 27
natans, 10: 121, 123-124
nodosus, 11: 27
pulcher, 10: 83
richardsonii, 10: 121-122
Potentilla palustris, 10: 83
Pottia truncata, 11: 11
Preissia quadrata, 10: 7, 9; 11: 11
Presettlement Vegetation of Rock County, Wisconsin, 10: 150-154
Prunus
serotina, 12: 220-228
virginiana, 12: 229
Psathyrella
kauffmanii, 10: 130
larga, 12: 196
obtusata, 10: 130
subagraria, 10: 130
Pteridium
aquilinum, 10: 196; 12: 169, 230
latiusculum, 12: 169
Ptilidium
ciliare, 11: 6
pulcherrimum, 10: 9; 11: 6
Ptilium crista-castrensis, 10: 10; 12: 216
Publications of Interest, 10: 43, 116, 207; 11: 79; 12: 78, 133-134, 194, 236
Pylaisiella
polyantha, 12: 216
selwynii, 12: 216
Pyrenolichens, Corticolous, of the Great Lakes Region, The, 12: 3-68
Pyrenula
imperfecta, 12: 43-44
macounii, 12: 45
neglecta, 12: 45-48
ssp. occidentalis, 12: 51
Pyrola rotundifolia, 12: 230

Queen Anne's-lace, 10: 198, 203
Quercus
alba, 12: 219-228
borealis, 12: 169
palustris, 12: 229
rubra, 11: 39-41; 12: 169
velutina, 12: 219-228

Radula complanata, 10: 7, 11, 12; 11: 7; 12: 216
Ramaria aurea, 12: 197
Rare Septobasidium on Scale Insects on Cornus Found in Michigan, A, 11: 74-77
Rare or Unusual Michigan Fungi of 1970, Some, 10: 75-77
Reboulia hemisphaerica, 11: 8
Reed, 10: 205
Reviews:
American Voyageur, 11: 121-122
The Archaeology of Michigan, 10: 62
Atlas of United States Trees, 10: 207
The Boletes of Michigan, 10: 93
Common Wild Flowers of Minnesota, 11: 12
Desmidiales Part I, 12: 136
Lake Superior, 10: 206
Michigan Flora, 11: 213-214
Narrative Journal of Travels, 10: 205
The North American Species of Psathyrella, 12: 137
The North Woods/The American Wilderness, 12: 128
Superior, 10: 206
Vaucheriaceae, 12: 136-137
Wild Flowers of Ohio and Adjacent States, 11: 37
Wildflowers and Weeds, 12: 135
Reznicek, T., & D. M. Britton, Chromosome Studies on the Spring Beauties, Claytonia, in Ontario, 10: 51-62
Rhodobryum roseum, 10: 7, 11; 12: 216
Rhododendron cumberlandense, 12: 89
Rhus
×borealis, 12: 169
glabra, 12: 169
Rhynchospora capillacea, 11: 31
Rhynchostegiella compacta, 11: 10
Rhynchostegium serratulum, 11: 10, 125, 127
Rhytidiadelphus triquetrus, 10: 7, 9; 11: 11; 12: 216
Riccardia
latifrons, 10: 12; 11: 7
multifida, 10: 12
palmata, 10: 12
pinguis, 11: 7; 12: 132
Rice, Marion M. (see Lytton J. Musselman et al.)
Rice, William E. (see Lytton J. Musselman et al.)
Roberts, Abby Beecher, 10: 46
Roberts, Marvin L., Wolffia in the Bladders of Utricularia: An "Herbivorous" Plant? 11: 67-69
Rock County, Wisconsin, The Flora of, 10: 147-193
Rogers, C. M., Changing Abundance of Two Species of Linum in Eastern North America, 10: 113-116
Rogerson, Clark T., & Samuel J. Mazzer, Two New Species of Hypomyces from

Michigan, 10: 107-113
Rosites caperata, 10: 130
Ruppia
occidentalis, 10: 119-121
maritima, 10: 121
Russula
borealis, 10: 131
emetica, 12: 197
fallax, 10: 131
ochroleuca, 12: 197

Saelania glaucescens, 12: 216
Sagittaria
cristata, 10: 124
cuneata, 10: 124
latifolia, 10: 124
rigida, 10: 124
Salix
bebbiana, 10: 83
gracilis, 10: 83
pedicellaris, 10: 83
Sample of the Seasonal Occurrence of Higher Fungi in Kalkaska County, Michigan, A, 10: 125-136
Sanguinaria canadensis, 12: 144
Sassafras albidum, 12: 220-228
Scale Insects on Cornus Found in Michigan, A Rare Septobasidium on, 11: 74-77
Scapania
gymnostomophila, 10: 7, 9
nemorosa, 10: 9; 11: 7
Scheuchzeria palustris, 10: 83
Schizophyllum commune, 10: 132; 12: 196-197
Schroeder, Gary J., & Rudy G. Koch, The Bryophytes of Amnicon Falls State Park, Douglas County, Wisconsin, 12: 212-216
Schwab, William A., Tipularia discolor in Southwestern Michigan, 11: 38
Schwab, William, with Frederick W. Case, Jr., Isotria medeoloides, the Smaller Whorled Pogonia, in Michigan, 10: 39-43
Scirpus
fontinalis, 11: 34
lineatus, 11: 34
pendulus, 11: 34
Scleria
hirtella, 11: 33
lindleyana, 11: 33-34
triglomerata, 11: 33-34
Scorpidium turgescens, 10: 13
Scypharia corium, 11: 167
Seasonal Occurrence of Higher Fungi in Kalkaska County, Michigan, A Sample of the, 10: 125-136
Segelken, John C., 12: 96
Selaginella
apus, 10: 195
rupestris, 10: 195
selaginoides, 10: 195
Seligeria
calcarea, 12: 107, 112
doniana, 12: 107
paucifolia, 12: 107
recurvata, 12: 107
Sematophyllum carolinianum, 11: 11
Septobasidium carestianum, 11: 74-77
Septobasidium, A Rare, on Scale Insects on Cornus Found in Michigan, 11: 74-77
Shinners, Lloyd H., 10: 95
Shoop, Darius R., 11: 35
Shrubs and Vines of Michigan, Field Key to Some Common, 11: 129-139
Silphium terebinthinaceum var. lucy-brauniae, 12: 89
Sisyrinchium
angustifolium, 11: 35
bermudiana, 11: 35
graminoides, 11: 35
montanum, 11: 35
Skavlem, Henry L., 10: 148
Smilacina trifolia, 10: 83
Smilax rotundifolia, 12: 227, 229
Smith, Alexander H., & Joseph F. Ammirati, Jr., Studies in the Genus Cortinarius, II: Section Dermocybe, New and Interesting Species from Michigan, 11: 13-25
Smith, Helen V., Wildflowers in Winter: A Project of the Michigan Botanical Club, 10: 197-205
Smith, Louis F., 11: 141-142
Snider, Jerry A., Chromosome Studies of Some Mosses of the Douglas Lake Region. II, 11: 125-128; III, 12: 107-117
Solenostoma
crenuliformis, 11: 7, 11
gracillimum, 11: 7
pumilum, 11: 7
Solidago
albopilosa, 12: 89
caesia, 12: 230
hispida, 12: 169
juncea, 12: 169
rigida var. glabrata, 12: 89
Some Rare or Unusual Michigan Fungi of 1970, 10: 75-77
Sorghastrum nutans, 11: 31
Southeastern Adder's-Tongue, Ophioglossum vulgatum var. pycnostichum, Found for the First Time in Michigan, The, 10: 67-74
Sparrow, Frederick K., 10: 95
Sphaerospora trechispora, 12: 197
Sphagnum
capillaceum, 10: 10, 83; 11: 8
centrale, 10: 84; 11: 8
dusenii, 10: 84
fimbriatum, 11: 8
fuscum, 10: 84; 11: 8
girgensohnii, 11: 8
magellanicum, 10: 83; 11: 8
obtusum, 10: 84
palustre, 10: 4
recurvum, 10: 84; 11: 8
squarrosum, 10: 4, 84; 11: 8
subsecundum, 10: 84; 12: 216

Spiranthes cernua, 11: 36
Spirodela polyrhiza, 11: 67, 69, 118
Spring Beauties, Claytonia, in Ontario, Chromosome Studies on the, 10: 51-62
Spore and Elater Ornamentation in Blasia pusilla, Comparative Micromorphology of, 12: 129-132
Stancer, Ovid P., 10: 46
Steccherinum adustum, 12: 197
Steere, William C., 10: 46; 11: 5
Stemonitis splendens, 12: 197
Stephenson, Stephen N., The Biosystematics and Ecology of the Genus Brachyelytrum (Gramineae) in Michigan, 10: 19-33
Stereum
complicatum, 12: 197
ostrea, 10: 131; 12: 196-197
Stewart, William G., & F. S. Cook, Four Interesting Moss Records from Southwestern Ontario, 11: 212-213
Stipa avenacea, 12: 230
Stropharia rugosoannulata, 10: 76
Stuckey, Ronald L., E. Lucy Braun (1889-1971), Outstanding Botanist and Conservationist: A Biographical Sketch, with Bibliography, 12: 83-106
Studies in the Genus Cortinarius, II: Section Dermocybe, New and Interesting Species from Michigan, 11: 13-25
Studies on Michigan Chrysophyceae. I, 11: 51-59; II, 12: 118-122
Succession, Forty Years of, on an Abandoned Building Site at the University of Michigan Biological Station, 12: 167-177
Suillus
americanus, 10: 129
intermedius, 10: 129
luteus, 10: 129
Summer Field Key to Some Common Michigan Trees, 10: 137-141
Summer Island, Delta County, Michigan, A Collection of Bryophytes from, 10: 3-13
Swezey, Goodwin Deloss, 10: 148
Synura, 11: 55
echinulata, 12: 120
petersenii, 11: 55, 57
sphagnicola, 11: 55, 57
spinosa, 11: 55, 57

Taxiphyllum deplanatum, 11: 11
Taylor, Jane, Gordon J. LeVee, Peggie J. Hollingsworth, & Wilbur C. Bigelow, Comparative Micromorphology of Spore and Elater Ornamentation in Blasia pusilla, 12: 129-132
Taylor, Jennifer, The Habitat and Orientation of Capsules of Buxbaumia aphylla in the Douglas Lake Region of Michigan, 11: 70-73
Tetraphis pellucida, 10: 12, 15; 11: 9
Tetraplodon mnioides, 11: 124
Thelephora
caryophyllea, 10: 131
terrestris, 12: 197
Thelypteris palustris, 10: 196
Thien, Leonard B., & Frederick Utech, Chromosome Numbers in Clintonia borealis (Liliaceae), 12: 122-128
Thieret, John W., Observations on Some Aquatic Plants in Northwestern Minnesota, 10: 117-124
Thistle, 10: 201
Thompson, Isabel, 12: 96
Thompson, Paul W., & James R. Wells, Field Key to Some Common Shrubs and Vines of Michigan, 11: 129-139; Oliver Atkins Farwell—A Reflection, 12: 69-73
Thuidium
delicatulum, 10: 10, 16; 11: 10, 125; 12: 216
recognitum, 10: 7, 10-11; 11: 10
Tilia americana, 12: 229
Tipularia discolor in Southwestern Michigan, 11: 38
Tomenthypnum nitens, 10: 10; 11: 10
Tortella
fragilis, 10: 7, 10, 13
tortuosa, 10: 7; 12: 108, 110, 112, 216
Tortula
norvegica, 11: 124
ruralis, 10: 12; 11: 124
Toxicodendron
radicans, 10: 31
rydbergii, 10: 32
Trametes malicola, 12: 196
Trees, Summer Field Key to Some Common Michigan, 10: 137-141
Trematodon
ambiguus, 11: 8
longicollis, 11: 212
Tremella
albida, 12: 197
intumescens, 12: 196-197
Tricholoma flavovirens, 10: 132
Tricholomopsis platyphylla, 10: 132; 12: 197
Trichostomum tenuirostre, 11: 9
Trillium
chandleri, 11: 34
grandiflorum, 11: 34-35
True, Rodney, 10: 148
Truman, Harry V., 10: 148
Tsuga canadensis, 12: 209-211
Tubaria furfuracea, 10: 130
Tubipeda, 11: 155
elastica, 11: 191
Tukey, Harold B., 11: 66
Turions, The Importance of, in the Propagation of Myriophyllum exalbescens (Haloragidaceae) in Douglas Lake, Michigan, 11: 115-121
Two Misunderstood Species of Gyromitra (False Morel) in North America, 12: 147-162
Two New Species of Hypomyces from Michigan, 10: 107-113
Tylopilus
indecisus, 12: 197

rubrobrunneus, 10: 107, 112
Typha latifolia, 10: 83

Ulmus americana, The Lichen Flora on, in Northern Michigan, 12: 163-166
University of Michigan Biological Station, 10: 46; 12: 143
University of Michigan Biological Station, Forty Years of Succession on an Abandoned Building Site at the, 12: 167-177
Utech, Frederick, & Leonard B. Thien, Chromosome Numbers in Clintonia borealis (Liliaceae), 12: 122-128
Utricularia
intermedia, 10: 83
vulgaris, 11: 67-69
Utricularia, Wolffia in the Bladders of, 11: 67-69

Vaccinium
brittonii, 12: 169
corymbosum, 12: 230
macrocarpon, 10: 83
oxycoccos, 10: 83
vacillans, 12: 229
Vallisneria americana, 10: 124
Van Faasen, Paul, The Genus Aster in Michigan. I. Distribution of the Species, 10: 99-106
Variability in Bark Morphology of Yellow Birch in an Even-Aged Stand, 10: 34-38
Veldman, Lorraine Calhoun, & Daniel E. Wujek, Pteridophytes of Beaver Island, Charlevoix County, Michigan, 10: 194-196
Verbascum thapsus, 12: 169
Verbena, White, 10: 201
Verpa conica, 10: 129
Vertical Distribution of the Lichen Genus Physcia on Bigtooth Aspen, Northern Red Oak, and Red Maple at Douglas Lake, Michigan, 11: 39-42
Viburnum acerifolium, 12: 229
Viola fimbriatula, 12: 230
Volvariella bombycina, 10: 132
Volz, P. A., & J. K. Weyer, Fungi of Lower Huron Metropolitan Park in Wayne County, Michigan, 12: 195-198
VonBokern, Thomas R., 12: 98
Voss, Edward G., Additional Nomenclatural and Other Notes on Michigan Monocots and Gymnosperms, 11: 26-36
Votey, Marjorie, 10: 95

Wagner, W. H., Jr., The Southeastern Adder's-Tongue, Ophioglossum vulgatum var. pycnostichum, Found for the First Time in Michigan, 10: 67-74
Wagner, W. H., Jr., & Stanley A. Cain, Dale J. Hagenah (1908-1971): An Outstanding Michigan Botanist, 11: 60-66
Ward, David, 11: 141-142
Watson, Samuel H., 10: 147-148
Wayne County, Michigan, Fungi of Lower Huron Metropolitan Park in, 12: 195-198
Weber, James A., The Importance of Turions in the Propagation of Myriophyllum exalbescens (Haloragidaceae) in Douglas Lake, Michigan, 11: 115-121
Weber, Nancy Smith, The Genus Helvella in Michigan, 11: 147-201
Weissia controversa, 10: 12; 11: 9, 126, 127
Wells, James R., Summer Field Key to Some Common Michigan Trees, 10: 137-141
Wells, James R., & Paul W. Thompson, Field Key to Some Common Shrubs and Vines of Michigan, 11: 129-139; Oliver Atkins Farwell—A Reflection, 12: 69-73
Wenger, Jerome D. (see Richard Brewer et al.)
Westward Extension of Hemlock in Wisconsin, A, 12: 209-211
Weyer, J. K., & P. A. Volz, Fungi of Lower Huron Metropolitan Park in Wayne County, Michigan, 12: 195-198
Wheeler, C. F., 11: 5
Whose Fight Was the Preservation of Nature? 11: 140-142
Wild Flower, 12: 92, 102-104
Wildflowers in Winter: A Project of the Michigan Botanical Club, 10: 197-205; 12: 254
Winter, Wildflowers in, A Project of the Michigan Botanical Club, 10: 197-205; 12: 254
Wisconsin, Douglas County, 12: 209-211; 212-216
Wisconsin, The Flora of Rock County, 10: 147-193
Withrow, Alice P., 12: 96
Wolffia
columbiana, 11: 67-69
punctata, 11: 67, 69
Wolffia in the Bladders of Utricularia: An "Herbivorous" Plant? 11: 67-69
Wood, Frank Elmer, 12: 70
Wood, Mary Cokely, 12: 70
Wujek, Daniel E., & Lorraine Calhoun Veldman, Pteridophytes of Beaver Island, Charlevoix County, Michigan, 10: 194-196
Wujek, Daniel E., & Ralph Hamilton, Studies on Michigan Chrysophyceae. I, 11: 51-59; II, 12: 118-122

Xanthoria
fallax, 12: 163
polycarpa, 12: 163
Xylaria polymorpha, 12: 196
Xyris
caroliniana, 11: 34
difformis, 11: 34
flexuosa, 11: 34

Yellow Birch in an Even-Aged Stand, Variability in Bark Morphology of, 10: 34-38

Zizania aquatica, 10: 118

MICHIGAN PLANTS IN PRINT
New Literature Relating to Michigan Botany

C. JOURNAL ARTICLES

Brose, David S., & Patricia S. Essenpreis. 1973. A report on a preliminary archaeological survey of Monroe County, Michigan. Mich. Archaeol. 19: 1-182. [Includes (pp. 5-6) a consideration of the original vegetation of the county.]

Chew, W.-L. 1969. A monograph of Laportea (Urticaceae). Gard. Bull. Singapore 25: 111-178. [*L. canadensis* is the only one of the 22 species in temperate North America; although the author saw dozens of Michigan specimens, only one is cited—with three errors—from Berrien Co.]

Crum, Howard. 1972. The geographic origins of the mosses of North America's eastern deciduous forest. Jour. Hattori Bot. Lab. 35: 269-298. [Concluding chapter analyzes origins of moss flora of Douglas Lake region (mostly Emmet, Cheboygan, Presque Isle, and Mackinac counties.]

Marsh, William M., & John M. Koerner. 1972. Role of moss in slope formation. Ecology 53: 489-493. [Role of *Polytrichum piliferum* on moss-covered sand slopes along Lake Superior between Pictured Rocks and Whitefish Point.]

Miller, Norton G. 1971. Three additions to the moss flora of New York state. Bryologist 74: 377-378. [Range of two northern species noted as known south to Straits of Mackinac.]

Payne, Willard W., Rainer W. Scora, & Junji Kumamoto. 1972. The volatile oils of Ambrosia (Compositae: Ambrosieae). Brittonia 24: 189-198. [Original collection locality for one of the plants of *A. psilostachya* analyzed was Muskegon Co.]

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INDEX NOTICE
To Librarians, Subscribers, and Binders

In this issue is a single cumulative index to volumes 10, 11, and 12 of THE MICHIGAN BOTANIST–our fourth triennial index. These three volumes may thus be bound together as a convenient unit with a single index. Note that all covers are included in the pagination and should be bound in. There are no special title pages.

On p. 237 are comments on the scope of the index: inclusions and exclusions.

Editorial Notes

We are again indebted to Miss Mary Cooley for her careful and painstaking work consolidating and alphabetizing the entries for the index in this issue.

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THANKS TO REVIEWERS

One of the chief functions of the members of the Editorial Board is to review manuscripts submitted for publication, considering botanical content, clarity of presentation, and suitability for this journal. All manuscripts are reviewed by at least one person. Reviewers are by tradition anonymous, but the editor takes this opportunity to express his appreciation to those who served on the Editorial Board during the past three years (names marked with an asterisk below) as well as to all others in this list, who have served as advisory reviewers for one or more articles submitted for volumes 10-12:

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CONTENTS

The Northern Limit of the Distribution of the Mockernut Hickory
Wayne E. Manning 203

A Westward Extension of Hemlock in Wisconsin
Donald W. Davidson, Rodger A. Ahlberg. Rudy G. Koch, & Duane J. Lahti 209

The Bryophytes of Amnicon Falls State Park, Douglas County, Wisconsin
Rudy G. Koch & Gary J. Schroeder 212

Composition of Some Oak Forests in Southwestern Michigan
Richard Brewer, David A. Boyce, James R. Hodgson, Jerome D. Wenger, Michael H. Mills, & Murray M. Cooper 217

Clavariadelphus junceus in Central Michigan
James Lampky 235

Publications of Interest 236

Index to Volumes 10-12 237

Michigan Plants in Print 254

Announcement: Winter Wildflowers 254

Editorial Notes 255

(On the cover: An opening pod of Common Milkweed, Asclepias syriaca, *photographed at Ann Arbor in October, 1971, by Helen V. Smith. A "Winter Wildflower"—see p. 254.)*

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